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PROGRESS REPORT
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NAS9-150

31 August 1962
4.5.41

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FLIGHT TECHNOLOGY (General Order 7121)

WIND TUNNEL PROGRAM

Wind tunnel tests completed during this report period are presented in Table 1.

During the next report period, launch escape system (LES) component loads and static stability characteristics of the Saturn-Apollo Block II launch and launch abort configuration will be determined at supersonic mach numbers in the Ames unitary wind tunnel.

The first aeroelastic tests of the Saturn-Apollo Block II launch configuration will be conducted in the Langley 16-foot transonic dynamics wind tunnel to determine the response to buffeting pressures and to measure the aerodynamic and structural damping in the first and second free-free bending modes.

Hypervelocity heat transfer test of the command module will be conducted for the first time in the Cornell Aeronautical Laboratory (CAL) 48-inch shock tunnel.

AERODYNAMICS

Command module and LES low supersonic dynamic stability data obtained in the Langley wind tunnel test series at mach numbers 1.60 to 2.75 have been analyzed. The command module shows stable damping in pitch and yaw except at the center of gravity nearest the apex. Reynold's numbers had little effect on the command module damping-in-pitch data, except at mach number 2.50, where the lowest Reynold's number showed unstable damping. The latest LES configuration (short tower) indicates that damping in pitch is unstable with washer on, except at mach number 2.50, where damping is stable with washer on and off.

Ground rules have been established to accurately define the procedure to ensure that the launch escape tower structural members do not foul alignment of the thrust vector for the pad abort case. They are as follows:

1. Jet impingement will be unacceptable for launch conditions below 5000 feet pressure altitude.



Table 1. Wind Tunnel Tests Program Completed August, 1962

Model	Facility	Mach Number	Test Dates	Objective
FS-2	NAA-TWT	0.2 to 3.5	6 to 10 Aug	Investigation of the command module second trim point and flow separation phenomena in the transonic regime
	AUPWT 9 by 7 ft	1.55 to 3.40	27 to 31 Aug	Determination of component loads of the assembled launch escape configuration
FS-3	AEDC-VKF-B	8.0	31 Jul to 3 Aug	Determination of basic aerodynamic characteristics of the command module at full-scale Reynolds number in the hypersonic range
FS-3A	AEDC-VKF-A	3.0 to 6.0	15 Aug	Feasibility of utilizing the reflection plane test technique to obtain angle-of-attack coverage of 0 to 360 degrees with a single model
FS-8	CAL 48-inch incl ST	15	15 to 20 Aug	Determination of the basic aerodynamic parameters in the hypervelocity range with real gas effects
FSL-1	AUPWT 11 by 11 ft	0.7 to 1.35	20 to 31 Aug	Determination of the basic aerodynamic characteristics of the Saturn C-1 boost configuration with and without the LES
FD-2	LUPWT	1.8 to 2.75	23 to 25 Aug	Determination of dynamic stability characteristics of the LES with the balance center of rotation located on the reference center of gravity
PS-1	AMES 2 by 2 ft	0.4 to 1.35	15 to 24 Aug	Determination of pressure distribution data on the command module at subsonic and transonic speeds
PS-3	AEDC-VKF-A	1.5 to 5.0	27 Jul to 7 Aug	Determination of pressure distribution on the command module with and without the escape motor and tower at or near full-scale Reynolds number
	AEDC-VKF-B	8.0	7 to 15 Aug	
PSTL-1	AMES 14 by 14 ft	0.7 to 1.2	9 to 24 Aug	Investigation of the transient pressures on the spacecraft during Saturn boost with and without the escape motor and tower in the transonic range

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2. The propulsion analysis group will determine the plume size characteristics from the latest information available from the motor manufacturer.
3. A 1/2-inch clearance will be required from any cross or diagonal brace of the tower structure to the calculated jet plume boundary.

Preliminary manufacturing tolerances for aerodynamic contour criteria have been determined for the command module.

Aerodynamic support to a study of a proposed 260-inch-diameter service module was completed.

Visits were made to the following ballistic range facilities:

1. Ballistics Range Laboratory, Aberdeen, Maryland
2. United States Naval Ordnance Laboratory, Silver Spring, Maryland
3. Canadian Armament Research and Development Establishment (CARDE) Quebec, Canada

Based on the examination of these facilities, it is recommended that tests of the command module alone be conducted in the Ballistics Range Laboratory and that tests of the LES be conducted in the CARDE facility.

The FS-2 model of the command module alone was tested subsonically in the transonic wind tunnel to determine the effects of Reynold's number on the second trim angle of attack ($\alpha \sim 60$ degrees). It was found that for $Re > 2.5 \times 10^6$ (based on command module diameter) a relatively strong trim point exists at $\alpha > 50$ degrees. During the tests, it was noted that an apparent Reynold's number effect exists for angles of attack near the primary trim point ($\alpha > 150$ degrees) for Mach number 0.2. The effects could not be fully investigated because of facility operation limitations. Investigations are being made during tests at other facilities.

Static pressure distribution data for the spacecraft were determined with a symmetrical model of the combined command module and service module. The data essentially define airloads design criteria for the service module and present a pressure distribution different from that which had been assumed. The present service module design is related to a 4.5 psi pressure differential; however, these data indicate that a much lower level is more realistic and that the pressures of the interface are much greater than those presently in design. The results indicate that the forward access

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fairings must be designed for a much higher bursting pressure than previously assumed and that the remaining service module loads are greatly relieved.

During the next report period, LES component loads will be determined from tests to be conducted in the Ames unitary plan wind tunnel.

Steady-state pressure distributions tests will be conducted on the launch vehicle model in the Ames unitary plan wind tunnel.

Motor calibration tests will be initiated using the hot-jet model (FSJ-1) in the Langley 16-foot transonic tunnel.

FLIGHT DYNAMICS

The LES thrust vector control system has been eliminated from consideration. It has been replaced by an acceptable passive system using a kicker rocket. The rocket has an impulse between 1200 and 3000 pounds seconds, and a burning time of 0.5 seconds. It is mounted near the top of the tower and is fired tangentially imparting the desired pitchover motion during the initial phase of abort. The main motor thrust has been revised downward from 180,000 to 155,000 pounds and has been aligned 2.8 degrees with respect to the center line. A down-range abort direction has been selected with the astronauts rotating heels-over-head.

Preliminary maneuver and orientation requirements have been established for a lunar landing mission that will include lunar orbital rendezvous. In satisfaction of these requirements, 964 pounds of propellant are required by the service module reaction control system (RCS). This propellant is required to damp rotational transients, perform angular orientation maneuvers, provide docking capability, provide propellant settling of the main tanks, furnish nominal midcourse correction capability, and perform separation maneuvers.

The technique for separation of the command module and service module from all last-stage boosters is presently being evaluated for both normal and abort modes of operation. Parameters affecting selection of the technique are redundancy criteria, performance trade-offs, mechanization complexity, and restrictive initial conditions for abort. Configurations considered include use of the service module RCS for separation and ullage, use of fire-in-the-hole by the service propulsion system with ullage provided by booster thrust tailoff, and use of special rockets attached to the service module, adapter, or booster upper stage to provide both separation and ullage.

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The recovery system is being investigated, and a comprehensive test plan including both a wind tunnel and an aerodynamic drop program has been released. The recovery envelope has been modified to decrease the maximum altitude for drogue deployment to 25,000 feet to account for the increased design weight of the command module.

An investigation of the fuel requirements for a manually-controlled entry maneuver has been conducted, and results are being evaluated. Fuel requirements and a realistic duty cycle will be available shortly.

Attitude orientation studies completed include arrestment of a tumbling command module following high-altitude abort above 125,000 feet. The studies indicated that the SCS can provide sufficient stabilization through the entry phase with the command module entering in either of the two possible trim conditions.

During the next report period, further evaluation of the LES will be conducted using revised system weights and aerodynamic data.

The performance of the LES with respect to both booster dispersion and explosion hazards will be investigated.

High-altitude abort tumbling conditions will be more fully investigated, and criteria will be established.

The requirements and design criteria for the service module RCS will be updated as the midcourse correction capability is more adequately defined.

Docking maneuvers will be investigated and a simulator study will be initiated.

Requirements for service module RCS thrust level will be further investigated.

The separation problem will be studied to determine a universal technique for separation from any proposed booster.

Additional investigations of the attitude orientation problem will be centered on investigation of manual reorientation and the effect of possible elimination of the apex forward aerodynamic trim point.

PERFORMANCE AND TRAJECTORIES

Trajectories for the C-1 and for the C-1 with the service module have been revised to reflect larger weights in the S-I and S-IV stages. The

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injected payload degradation for the two-stage C-1 vehicle is 2573 pounds; the payload for the C-1 with the service module is 948 pounds.

The boost trajectories for the C-1 with the service module were computed to determine the influence of service module ignition delay on the orbital payload. The performance trade-off study shows a reduction in payload of 10.4 pounds per second of ignition delay.

A typical C-1 boost trajectory has been calculated for the SA-9 flight (heat shield entry). A ΔV margin of 2192 feet per second remains for the S-IV stage with the current payload of command module, service module, and adapter. Conversely, an available payload margin of 6837 pounds with no ΔV margin exists for the boost vehicle required cut-off conditions.

The payload variation for the C-1 using two stages to apogee of 150 nautical miles has been determined for suborbital velocities. Although this particular trajectory is not optimum for simulation of an orbital entry heat shield test, it is the maneuver currently defined by NASA for the SA-10 mission.

A propellant trade-off study has been completed to determine the maximum orbital (100 nautical miles) payload capability for the Saturn C-1B. The optimum usable propellant loadings were 799,386 pounds for the S-1 and 211,551 pounds for the S-IVB. The S-IVB cut-off weight was found to be approximately 1.7 percent greater than comparable NASA values.

Convair has announced that the fins will be 50 square feet for all Little Joe II tests. This will necessitate a change in the maximum q abort trajectory calculated for 150-square-foot fins. This reduction in size, which will result in a reduction in drag, will enable Little Joe II to perform the max q abort test with two Algol motors rather than three.

NASA wind data received for El Paso, Texas, is to be considered applicable for the White Sands Missile Range. These data will be used for wind dispersion studies and loads data for the Little Joe II test trajectories.

Trade-off studies have been completed to determine the most desirable propellant capacity for the service module. Based on anticipated growth factors, the optimum propellant weight is between 42,000 and 45,000 pounds. By comparison, the propellant weight obtained using NASA ground rules is approximately 40,500 pounds.

A revised series of heat shield design trajectories is being prepared for Avco. These trajectories represent the extremes of heating rates and

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loads that the command module will encounter in all Apollo mission phases in nominal design trajectories and abort situations.

The effect of seasonal deviations from a representative atmospheric density profile on the entry corridor is being studied. Preliminary results indicate a reduction in the corridor depth of approximately five percent from that of 1959 STD ARDC atmosphere.

A preliminary evaluation of the NASA-recommended ΔV 's and ground rules for the lunar excursion module mission has been completed. The ΔV requirements were computed as a function of time for January 1967 for landing at the MSC site, 2.5 degrees north and 36.5 degrees east (selenographic coordinates) and for subsequent return along the GOSS track. It was found there were two areas on the lunar surface that could be reached during this time period using the NASA ΔV capabilities. One area was on the trailing visible quarter, and the other was on the leading nonvisible quarter. Each area contains approximately two percent of the lunar surface. The NASA ΔV for the lunar excursion module pickup maneuver in the abort mode was found to be low. Use of a more efficient maneuver into the equal period orbit will permit a lunar excursion module pickup maneuver with ΔV to spare. The NASA velocity increments for lunar orbit injection and transearth injection did not permit overfly of the proposed landing site at all times of the month; however, sufficient ΔV allotted for plane change maneuvers can be provided to accomplish overfly and return. The NASA ΔV 's were found to permit the use of two earth-launch windows.

A meeting was held concerning interrelationships between spacecraft performance, trajectories, systems reliability, mission success, and crew safety. S&ID presented an over-all plan of action to review mission success and crew safety criteria and status in certain technological areas.

Translunar midcourse correction maneuver requirements were investigated with variations in translunar injection errors and translunar reference trajectory characteristics. Total maneuver requirements were from 13 to 42 feet per second, 1σ , depending on coast angle and reference trajectory. Maneuver pointing errors from 0.0167 to 0.30 degrees had no significant effect on the ΔV requirements. Thrust cut-off deviations, which result in velocity magnitude errors, produced a large variation in ΔV requirements up to 282 feet per second for a 2-second cut-off error.

During the next report period, studies of the effect of lunar operational and trajectory constraints on the required characteristic velocities will be continued. Investigations will consider time-of-the-month effects, lunar surface coverage, stay time on the lunar surface, and earth-entry range.

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The booster load trajectories for the various missions will be established. They will include the latest weight and performance data from NASA.

The major portion of the performance parametric trade-offs for establishing navigation and guidance requirements should be completed. These studies will cover all phases of flight, such as boost, translunar, lunar-orbital operations, transearth, and entry.

Boost and entry trajectory analysis for the development flights and for the flight plan studies will be continued so that the requirements for the boilerplate orbital test, high-altitude abort test, and prototype orbital test maybe completed.

THERMODYNAMICS AND SYSTEMS ANALYSIS

Aerothermodynamics

The Apollo entry heating program has been revised to permit the simultaneous, independent, computation of aerodynamic heating rates at thirty points on the command module. This program can handle nine trajectories simultaneously. It also provides an output in the form of cathode ray tubes plots and printed tables of heating rates as a function of time.

The equations are basically unchanged from the previous program except for the radiation analysis and the convective heating distribution on the entry afterbody. A radiative-heat-transfer rate, using Meyerott's emissivity data, has been incorporated in the program.

A program to compute heating rates due to rocket plume impingement has been completed.

A correlation has been made of the heat-transfer data obtained in the JPL wind tunnel of the launch configuration without LES, and of the heating rates for an apex forward entry after high-altitude abort.

During the next period, entry-trajectory heating rates, based on a command module gross weight of 9500 pounds and a range capability of 5000 miles, will be computed using the new program.

Wind Tunnel Program

Data evaluation of the JPL H-1 heat transfer test results was continued. A final report is almost complete.

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Reduced data from the AEDC H-2 tests were obtained and plotted by the cathode ray plotter. Data evaluation was started.

The H-2 models returned from AEDC were modified for testing in the Langley unitary plan wind tunnel. Construction of the HL-1 model is nearing completion. It will also be tested at LUPWT.

Agreement was reached with NASA on a minimum-heat-transfer test program to be accomplished with the 0.04-scale H-7 model in the Hotshot-II tunnel at a Mach number of 20.

Wind-tunnel tests are in progress to determine aero heating in the command module's RCS rocket nozzles during entry. Tests are also being conducted to determine service module heating surface due to impingement of the RCS rockets.

During the next period, H-1 data evaluation will be completed and H-2 evaluation will be continued.

Shock-tunnel testing will be started at the Cornell Aeronautics Laboratory. Final preparations for the Langley tests will be completed.

Heat Transfer Analysis

Launch Escape System

An analysis of the flow separator for the LES during boost has revealed that fiberglass insulation 0.2 inches thick will be required to prevent the upper face panel of the flow separator from exceeding 600 F.

The test program for the LES tower ablative material was revised to include additional test data. All test specimens have been prepared, and the required test equipment has been fabricated.

An analytical study will be made during the next report period to determine the amount and kind of material required to provide adequate thermal protection for the LES tower structure during abort. An estimate of the effects of particle impingement from the exhaust of the LES motors will be included in this investigation.

Ablative materials for the thermal protection of the LES tower will be tested in rocket exhausts comparable to those of the LES motors.

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Boilerplate Test Articles

An analysis of the thermal protection requirements for the boilerplates during C-1 boost indicates that protective material will not be needed in the region from 2.7 feet to 4.6 feet aft of the stagnation point measured along the surface of the vehicle. Other regions of the vehicle are now being investigated to determine their thermal protection requirements.

During the next report period, work will continue on a study to determine if any portions of the boilerplate aft of 4.6 feet will require thermal protection.

Command Module

A study has shown that the weight of ablation material on the command module can be reduced by approximately 460 pounds if the bondline temperature limit at touchdown is changed from 400 F to 800 F. This weight reduction includes consideration of the additional insulation required on the afterbody for the 800 F condition.

Additional items were accomplished as follows: curves of temperature versus time for the stainless steel and aluminum honeycomb face sheets were prepared; calculations were made of temperature distribution through the heat shield at critical times during re-entry; test specifications were completed for the first series of twenty planned arc-jet tests; details of the heat-shield qualification test program were prepared.

A preliminary study to determine the minimum surface temperature of the command module during space flight was completed. Results indicate that when the surface is shaded from sunlight for prolonged periods, the structure may cool to -287 F.

Water-bottle environment temperatures have been predicted for entry, parachute-deployment and post-landing conditions. Estimates indicate that the temperature of the air surrounding the water tanks may be as high as 400 F for approximately 30 seconds. This occurs when the impact attenuation mechanism is operated during drogue-chute deployment.

A heat-transfer study was made to determine the temperatures of the propellant tanks for the RCS during reentry. Results show that overheating of the uninsulated tanks may occur during this phase.

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During the next period the following will be performed: (1) an evaluation of the electrical and thermal properties of antenna window materials will be initiated; (2) holes, cracks, and protuberances will be evaluated as they affect ablation performance; (3) an analysis will be performed to determine if the temperature of the outer skin of the inner cabin will exceed 200 F in the region where the aft-compartment frames are located. Studies will also be made to determine the thermal protection necessary to prevent overheating of the RCS tanks during entry; (4) temperature distribution within the command module will be determined (for lunar orbit) with the spacecraft in lunar orientation.

Service Module

The insulation requirement of the RCS tanks has been determined to be 0.25 inches for the translunar, lunar-orbit, and transearth phases when the main engine tanks are insulated.

A parametric study was performed for the RCS fairing during the boost phase. The maximum temperature that the RCS rocket arm will reach during boost is 700 F.

The main-engine injector plate will require an external heat source of 94 watts during the lunar mission.

A water table has been designed, fabricated, and operated to demonstrate the feasibility of various design approaches to the service module rocket-exhaust-and-separation problem.

Temperature histories of the feed lines were determined for the earth-orbital, circumlunar, and lunar-orbital flights. For the earth orbital flight, with 1.0 inch of super insulation on the feed lines (2.5 inches in diameter), it was found that heating of the lines must be begun 182 hours after launch in order to keep the propellants from freezing. For circum-lunar and lunar orbital flights, the propellant feed lines remain within the safe temperature range if one inch of super insulation is used.

A study was completed which determined temperature histories and gradients of the service module adapter during boost. Based on a maximum allowable temperature for the aluminum honeycomb panel of 375 F, results of the study indicate that (with a core having a density of 216 pounds per cubic feet) any face thickness greater than 0.019 inches could be used. With a core having a density of 3 pounds per cubic foot, any face thickness greater than 0.0165 could be used.

Insulation requirements have been determined for the propellant tanks. Results indicate that a minimum of 0.25 inches of high vacuum,

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"super" insulation will be required on the propellant tanks to prevent freezing of the propellant.

Studies are planned for investigation of the temperature histories of the cryogenic storage tanks during space flight.

Environmental Control Systems Analysis

Atmospheric Composition and Control

A study of humidity levels in the command module indicates that excessive "sweating" would be encountered on the suit circuit and coolant ducting unless sufficient insulation were installed.

A computer program was developed to optimize insulation requirements. The study has been completed, and the insulation thickness has been established. This thickness varies from 0.392 to 1.45 inches.

A preliminary report has been completed as the result of a literature search into fire hazards in 100 percent oxygen and oxygen-enriched atmospheres. This report indicates that limited testing will be warranted.

The effect of meteoroid penetration on the command module atmosphere is being investigated. A test program geared to monitor the atmospheric effects of meteoroid penetration is being considered. This test would be conducted in conjunction with the proposed meteoroid test program.

Compressor performance curves for three cabin pressures were integrated into the suit-circuit-computer program. Preparation of a "sub-program" for the incorporation of new and more general compressor data is in the initial checkout stage.

The waste management system analysis, including a new selection valve, revised tubing lengths, odor removal filter, and three check valves, was completed for a 5.0 psia command module pressure. There was only a small change in the flow rates through the separate branches as a result of the change to 5 psia.

The use of 3/8-inch outer diameter tubing for urinal and fecal ventilation lines, and 5/8-inch outer diameter tubing for the return line from the exhaust blower, were established as the optimum sizes. Although ventilation line lengths from the storage area have not yet been defined, the estimate of 1/4-inch outer diameter appears to be valid.

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During the next period, the following will be accomplished: (1) the latest component-pressure-drop characteristics and 5 psia study capabilities will be integrated into the computer program; (2) a detailed study of the heat exchanger effectiveness and performance requirements is expected to be started; (3) the fire hazard in a 5 psia oxygen atmosphere will be defined; (4) a test outline will be completed of meteoroid penetration effects on the cabin atmosphere; (5) the computer program for the water-management system is expected to be completed and production runs made; (6) a sample of the fecal bag developed by S&ID, will be tested for cabin-depressurization-effect. The tests will be conducted concurrently with scheduled cabin-simulation tests.

Unmanned Spacecraft

The basic system for cooling instrumentation on the pad abort and maximum q boilerplate test vehicles has been sufficiently defined for design purposes. Additional analysis indicates that the same basic cooling system, which utilized pre-cooled water-glycol as a heat sink, is adaptable to the first orbital vehicles (boilerplate 13 and 15). This system will supply cooling for all the electronic equipment during prelaunch and boost. During orbit, the system is capable of cooling one coldplate-cooled telemeter unit for one orbit only, as required by the mission objectives.

Planned activities are as follows: limited performance tests will be conducted on the complete system as soon as all components have been procured; additional studies on the orbital boilerplate vehicles (boilerplates 13 and 15) will be made as soon as more data become available; an analysis will begin of cooling requirements for boilerplates 16 and 18.

Equipment Cooling

The weight penalty for the incorporation of redundancy within the electronic cooling system has been analyzed for 33 possible system combinations.

A computer program has been written that simultaneously solves the flow-and-temperature distribution within a coldplate. This program evaluates changes in fluid viscosity, specific heat, and density as a function of temperature while solving for fluid distribution and heat transfer through the coldplate.

The problem of heat dissipation for a lighting unit mounted on a seat shock absorber was examined and completed.

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A literature search for a thermal interface material to be placed between the electronic units and the coldplates was continued, and several materials were chosen for testing.

Tests of the first developmental coldplate have been completed, and the test data are being reduced and analyzed. So far, the test results show good agreement with the analytical results.

Coolant-flow-versus-pressure-drop tests were run on the first honeycomb sandwich coldplate. A second honeycomb sandwich coldplate has been completed and satisfactorily bonded. This plate is identical to the first one, except that thermocouples were installed internally before bonding, so that the plate could be used for thermal tests. The plate has been leak-checked, pressure drop tests have been run, and its surfaces have been machined and lapped to improve their flatness and finish.

During the next period, a trade-off study of weight-versus-reliability is planned for the 33 possible system combinations now under consideration to determine the optimum system for incorporation of redundancy within the electronic cooling system.

The computer program for the simultaneous solution of mass and heat transfer for a single coldplate will be enlarged to permit an evaluation of changes in the fluid film coefficient as a function of temperature and flow. The same computer program now used for the analysis of a single coldplate will be adapted for the analysis of electronic cooling systems comprised of multiple coldplates. Interface material samples will be tested to determine the interface conductance between the aluminum test plates.

Nuclear Radiation Protection Systems

Integral energy spectra are complete for 14 solar proton events. The service module geometry breakdown is completed. The service module is divided into 83 solid-angle segments. The density and thickness, in grams per square centimeter, for each type of material in each segment, have been computed. The advance computer shielding program has been initiated. A general solution of the linear-energy-transfer function for low-energy protons applicable to any number of layers of material has been determined for the primary proton dose. Planning for the accelerator-verification studies connected with the advanced computer shielding program is near completion. Nuclear and warning instrumentation requirements have been further defined, and specific hardware systems are now under consideration.

During the next period, differential energy spectra for 25 proton events will be determined. Solar phenomena studies for use in a warning system are planned. The command module will be divided into more than 50 solid segments, including shielding characteristics of each.

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The computer program for determining the dose rate for the 25 energy spectra will be run. Possible accelerator facilities for implementing the shielding verification effort will be explored.

Power Systems Analysis

Over-all Power System

Two methods of rejecting heat during the prelaunch operation were analyzed, and a parametric study of heat exchanger requirements was initiated for this application. The times required for system cool-down, to permit fuel cell replacement and maintenance have been calculated for several cooling modes.

During the next period, heat rejection methods will be optimized, methods for reducing cool-down time will be determined, and effects on system reliability will be analyzed.

Fuel Cell Subsystem

Steady-state temperature gradients have been determined for fuel cell electrodes under critical operating conditions. A computer program has been designed to permit determination of transient temperature gradients.

The computer program for transient analysis will be checked out during the next reporting period, and thermal stress levels associated with the temperature gradients will be determined.

Cryogenic Storage Subsystem

Cryogenic subsystem design parameters were determined using 3 percent ullage. The data (curve sheets and tables) are placed in the Design Data Manual. A specification is being prepared which describes fluid delivery rates, fluid properties, and suggested line sizes for the delivery of oxygen and hydrogen to the command module by GSE. An analysis has been made of an initial pressurization by warm gas. This procedure requires more complex GSE equipment to insure the same fill weight for all periods of stand by, although these requirements do not appear excessive. Analyses were completed of the total heating requirements (to maintain tank pressure and to warm delivery gas) for the cryogenic subsystem during the entire mission.

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Space Radiator Subsystem

Analyses were initiated for resizing and determining the control characteristics of the ECS and EPS space radiators for the lunar-orbit mission. These studies will reflect the elimination of the deployable ECS radiator and the lunar landing requirement. Curves are completed which describe the heat-rejection capabilities (water-glycol outlet temperatures and rejected-heat-versus-position in earth orbit) for the ECS radiator. Plans are completed for the testing of eight different space-radiator-coating samples on the S-17050 (Orbiting Solar Observatory).

The size and controllability analysis of the ECS and EPS radiators for the lunar orbit mission will be continued during the next report period. Surface-coating-sample candidates for the test in the Orbiting Solar Observatory (OSO) will be screened and submitted to NASA for installation on the OSO. The analyses of radiator performance requirements for the lunar-orbit mission will be continued. The ECS and EPS radiators will be re-sized for the critical lunar-orbit heat-rejection requirements and environmental parameters.

Propulsion Systems Analysis

Propellant Feed Systems

The SPS pressurization system is being studied to determine comparative weight and performance without heat addition, and with various methods of heat addition to the helium. Two methods of heat addition under consideration are bubbling of the helium through the propellant and a propellant-to-helium heat exchanger. Parametric data are developed which show the effect of heat addition on helium-bottle-size requirements. The size of the SPS propellant tank fill-and-vent lines in the service module is determined. The oxidizer line is 1 1/2 inches inner diameter, the fuel line is 1 1/4 inches inner diameter, and the vent line is 1 inch inner diameter.

Pressure drop requirements of the SPS propellant-utilization valves are determined for: (1) the case of an automatic and manual valve, in parallel, located in the oxidizer line; (2) and for the case of separate automatic and manual valves, in series, located in both the fuel and oxidizer lines. Results indicate that the pressure-drop range is smaller and the system weight is less, for the propellant-utilization valves in both the fuel and oxidizer lines.

The pressure surge (water-hammer effect) in the RCS of the service module is determined as a function-of-line inside diameter and number of motors firing. Marginal conditions are found to exist (over 500 psi surge) with 3/8-inch line and 3 motors firing.

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A study to determine the minimum size of the helium reservoirs of the command module RCS pressurization systems is complete. Results indicate that spherical reservoirs having an inner diameter of 8.1 inches will be required for the present command module RCS propellant system.

A study to determine the effect of propellant-tank pressure on system weight is complete. Increased pressure in the propellant tanks resulting from a requirement of higher pressures at the engine will affect system weight through the principal effects of helium weight, helium reservoir weight, and propellant tank weight. Results indicate that an increase in propellant tank pressure of approximately 175 psi will result in a weight increase of approximately 4.5 pounds for each system.

A propulsion system analog-simulation program was initiated to investigate the transient and steady-state behavior of the propellant and engine systems of the command and service modules.

A computer program for detailed analysis of propellant pressurization systems will be completed during the next reporting period. The detailed analytical data required for propellant pressurization system trade-off studies will be developed. The test programs required to provide basic data for analyses, and to substantiate them, will be initiated. Weight and performance optimization studies will be continued.

Rocket Engine Systems

As the result of a service propulsion system optimization study, the engine-nozzle expansion ratio is increased from 40:1 to 60:1.

A study is completed concerning the effects of a service module main engine propellant valve failure on engine-mixture ratio and other engine performance parameters. Results of this study indicated that an adjustment of the impedance relationship between the fuel and oxidizer systems could give a constant engine-mixture ratio even during failure conditions. However, a slight decrease in engine thrust would occur.

An analysis covering the effects of helium entrainment in the propellant lines on service-module main-engine performance is underway. Methods are under investigation to separate the gas from the propellant before it enters the engine.

A transient, one-dimensional, heat-transfer analysis is under way to determine temperature gradients and the time required to reach quasi-steady-state conditions through the tower jettison motor and the launch escape motor grains.

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A study is under way for investigation of various factors affecting the launch escape motor thrust-line alignment. The factors considered are asymmetric and axisymmetric erosion, variation of thrust coefficient with nozzle geometry, asymmetric and axisymmetric nozzle shocks, chamber pressure perturbations, variations of the specific heat ratio in real nozzles, and gas malalignment.

An optimization study of the command module RCS utilizing an ablative thrust chamber is in progress. This investigation is to determine an optimum weight system and major corresponding thrust-chamber parameters compatible with over-all system requirements.

An investigation of thermal effects on the service module RCS engine and the engine material limits is in progress.

A preliminary analysis of the operating characteristics of the service-module main engine is complete. This information, together with pulse-operation characteristics of the RCS engines, is presently being revised.

An investigation of the RCS and main-engine propellant-consumption rates, for various operating conditions, is underway.

The heat-transfer analysis of the Apollo solid-propellant motors will be continued during the next report period. The investigation of the critical parameters affecting the launch-escape-motor thrust vector will be continued. An optimization study of the command-module RCS will be carried out. An investigation into the adaptation of a computer program for use on ablative thrust chambers will be initiated. The study of the effects of gas entrainment in the propellants on the service module main engine will be continued. Simulation of zero-g effects to determine methods of eliminating gas entrainment will be included in this study. The analysis of the propellant consumption rates as a function of engine operating conditions will be continued.

Interface Systems

Gas properties in the command module RCS nozzle and nozzle extension are being calculated. This information will be used in calculation of the exhaust plume heating and side-thrust from the scarfed nozzle. A study was made with the following results: (1) design charts were developed showing the relationship between the required blow-out panel area and the adapter length; (2) design charts were developed for optimization of the configuration utilizing an isentropic spike for exhaust flow deflection; (3) a two-dimensional water table simulation of the different interstage configurations was developed and operated to illustrate qualitatively the relative effectiveness

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of each configuration; (4) the weight requirements of solid propellant separation rockets were estimated. LES exhaust plume boundaries were also determined in order to evaluate the extent of tower impingement. These contributed to the redesign of the LES motor.

A detailed test plan for the Tullahoma simulation tests of the service-module RCS will be released during the next report period, the IBM plume program will be completed and LES thrust deflection and plume heating of the command module and tower will be completed for the latest configuration.

SIMULATION EVALUATION AND COORDINATION

Ablation Tests

The fabrication of two wedge-type ablation specimens instrumented for temperature measurement were completed. These will be exposed to the Mach 3 plasma stream at the Plasmadyne Corporation 1-megawatt facility. Four additional plug models are being fabricated for exposure to a similar environment.

Gas samples were obtained and analyzed for the study of the gas composition of the ablative heat shield exposed to simulated thermal environments. Testing was completed, and results were submitted for evaluation.

Temperature Control Coatings

Development and optical tests of the ECS fuel-cell thermal-radiator coatings are under way and environmental tests of candidate coatings have been initiated.

Simulated Space Spheres

Effort on the 4-foot diameter space sphere is completed. Test and evaluation will be defined during the next period.

Tool, materials, and fabrication estimates for the space sphere are complete. A report is being prepared. Test results on typical construction material composites will be released when the test data are available.

Anti-Gravitational Suspension Platform

Effort on this platform is completed, and the unit is ready for delivery.

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~~CONFIDENTIAL~~Apollo Vision and Lighting Dome

A preliminary drawing of the general configuration requirements for the Apollo vision and lighting dome is completed, although materials call-out and details are still pending. The unit will have a 20-foot over-all height, with a 33-foot reinforced, laminated dome, and a circular, 43-foot base. Additional space is being requested for housing of this item. Operational procedures will be prepared.

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INTEGRATION AND SYSTEM ANALYSIS (General Order 7122)

CONFIGURATION CONTROL

Progress has been made in the determination of time-phasing for spares configurations compatible with vehicles fabricated after initial releases of spares equipment. These data will be used in configuration-control documentation. Changes in the water-glycol environmental control system (ECS) circulating loop prevented release of the Little Joe-II interface coordination documents (ICD).

The preliminary instrumentation unit ICD is complete and will be released as soon as coordination with Huntsville is complete. Work is under way on the White Sands gantry and Little Joe-II interface.

The original list of interfaces is being reworked to reflect a more comprehensive list of interfaces by title, number, and responsibility. This list will be distributed and kept current. The functional schematic, indicating the interrelationships of systems on boilerplate 6, is now 70 percent complete. All information has been obtained except for the schematics from NASA. The systems perspectives drawing, "Configuration Arrangement for Boilerplate No. 1," was released.

Command module drawings reflect the latest inboard profile changes for the lunar excursion module. The change from 140 inches to 155 inches for the service module was incorporated into these drawings. Revisions in boilerplate 20 are being incorporated into boilerplate 6. The inboard profile for boilerplate 3 was dropped.

Marking drawings and three-view drawings of boilerplates 1, 2, 3, 5, and 19 are scheduled for release during the next reporting period.

SYSTEMS INTEGRATION

A committee is established for the installation of Apollo electronic systems, controls, and displays. A concept for performance of systems-compatibility-and-integrated checkout of electromagnetic-interference tests has been established. This concept requires the utilization of a large shielded enclosure capable of accommodating the spacecraft and a building-block technique of spacecraft-vicinity-checkout equipment.

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Instrumentation discrepancies in information from NASA on boilerplates 6, 12, 20, 21, and 23 were recapitulated with NASA. Meetings were also held to resolve the umbilical lists for the abort boilerplates.

The umbilical-arm study for the service tower of complex 39 has been reviewed, and the umbilical plug for the boilerplates has been chosen.

Physical, functional, environmental, and operational interfaces are established. The major portions of the physical interface are defined and documented. The functional, environmental, and operational interface definitions are started.

Twelve different interface problems involving the stabilization and control system (SCS) and navigation and guidance studies are being monitored and investigated. Priority is being given to the propulsion, SCS, and navigation and guidance requirements during navigational sightings; and to the role the navigation and guidance computer will play in integrated checkout of the navigation and guidance and stabilization and control systems.

Work is being done on a digital-computer program for system-interface analysis. A program for logic-circuit analysis has also been written. Work is under way on the preparation of an interface analysis document for all mechanical systems. This document will be used to record all interface evaluations. Interface drawings on the "Q" ball are released.

Analysis of the electro-explosive devices resulted in a reorientation of the application of exploding bridge wire and hot-wire initiators. Hot-wire initiators will be utilized in all presently established spacecraft applications with the exception of the launch escape system (LES) propulsion system.

A preliminary checkout procedure for the ECS has been prepared and is now being revised.

Information concerning integrated-system-checkout requirements for boilerplate 6 was released. A list of ground rules was prepared for selection of the measurement points to be used by GSE during integrated-system checkout. Requirements for system-phasing checks during integrated-system checkout are being prepared, and a document has been prepared to provide the ground rules for placards and limitations guides. Definition of the data-transmission system for AMR is progressing.

Requirements for an integrated checkout of boilerplate 6 will be complete during the next report period. The first draft of the interface specification for Little Joe-II will be released. The format for the Interface Analysis Document will be established. A list of all interfaces will be prepared in order to define the overall interface-analysis effort.

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TEST INTEGRATION

Measurement Lists

Operational measurement lists were completed for airframes 007, 010, and 011 to determine the size of the pulse-code modulation system. The number of channels for each sample rate and size of the system have been determined. This information was used by the subcontractor in preparing a request for bid.

A parameter numbering system has been devised. This system will automatically control the measurement lists for all vehicles and will facilitate the automatic data reduction and transmittal of up-to-date lists to NASA at Houston, Cape Canaveral and to all interested subcontractors.

Heat Shield Program

The proposal to augment the present thermal-protection-system test program with a more comprehensive heat-shield development program is well under way.

Propulsion System Test Plan

A preliminary detailed test plan was prepared and submitted for the propulsion tests on airframe 001 to aid in justification of the facility at White Sands. This plan will undergo revision as further tests and requirements are received.

Test Requirements for Various Vehicles

Test requirements have been requested and are being gathered for the pad abort, boilerplate 13, house spacecraft and propulsion spacecraft.

Integration Studies

A final report on the feasibility of utilizing a service module with a 260-inch base will be completed during the next report period.

A study of the RCS throughout the lunar-landing mission will be completed during the next period.

Program Integration Engineering

An analysis is being conducted of the prelaunch operations director-generated AMR ground operational flow diagram.

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Work continues on the long-range study program concerning the effect of the Apollo spacecraft configuration on mission success. The mission-failure analysis program continues. The effects of component failures in a given mission or system are being analyzed.

A reevaluation is being made of electrical loads requirements to reduce the peak and average-power requirements by means of a careful analysis and phasing of equipment duty cycles. The results will be presented to NASA during the next reporting period.

PROJECT REQUIREMENTS

The Summary Definitions and Objectives Document has been released with revisions according to NASA's redirection. This revision was to incorporate the lunar-orbiting rendezvous concept, without lunar excursion module integration and a revised master phasing schedule, which depicts the deletion of the second-stage service module. The Apollo Mission Requirements and Apollo Spacecraft Requirements Specifications have been reoriented and released. They now reflect the lunar orbital rendezvous mission without lunar excursion module integration.

A report on the feasibility of a 260-inch-base service module has been sent to NASA.

The lunar excursion module interface study has been coordinated; an Apollo lunar excursion module combined-system schematic and interface are defined; and a preliminary Apollo lunar excursion module interface specification is completed.

Formal changes have been initiated for the Category-I, II, and III weight reduction changes. These involve change of the ECS to 5.0 psi pure oxygen atmosphere, elimination of the impact attenuation system, and installation of five windows.

The Apollo Effectiveness Optimization Study Plan is in use.

A report has been released describing the Algebraic Logic Investigation of Apollo Systems (ALIAS) method and its application to contingent operations analysis.

The summary definitions and objectives document will be revised, as required, to reflect changes in program direction. The summary definitions and objectives for mock-ups, boilerplates, spacecraft, evaluators, simulators, test fixtures, and trainers will be released during the next report period.

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Documents applicable to the contract will be tested and delivered to NASA. A plan-of-action for the establishment of a critical matching spacecraft-support parts list is being prepared. The Apollo ground operations requirements specification will be released. This specification will include the system-flow-and-checkout concept for AMR operations.

MATERIALS AND PRODUCIBILITY

A survey of sealing materials and methods for nitrous tetroxide revealed that all existing organic-sealing materials (particularly elastomers) have a relatively high pressure to nitrous tetroxide, which increases rapidly with a temperature above 70 F. S&ID determined that a suitable nitrous tetroxide-resistant rubber may require two to three years of developmental work. A test plan to determine the single and combined effects of hard vacuum and ionizing radiation is being prepared. S&ID has confirmed the feasibility of machining the crew hatch design features of the command module, either by conventional Hydro-Tel milling machines or by five-axis tape-controlled machines. Numerous proposed parts and drawings were reviewed involving the use of titanium in welded parts and titanium machined from bar stock.

The differential equations for a toroidal shell have been derived. Assumptions have been made as follows: (1) the deflections are relatively small; (2) the thickness of the shell is small in comparison to the radii; (3) plane sections remain plane; (4) thermal gradients exist both radially and along the surface; (5) the loading is non-uniform; (6) the flexural and extensional properties of the shell are not constant. The differential equations for the sphere and the cone have been obtained by the differential equations.

The differential equations have been expanded into a finite difference form for solution on a digital computer. The finite difference equations, as written, are for equal differences and are valid for continuous functions.

The boundary conditions for the shell have been formulated and expanded into a difference form. The toroid and sphere will be associated by the conditions of compatibility and equilibrium.

At the present time, the stiffness matrix for the heat shield is being formulated, and the programming of stiffness matrix is beginning. Thermal shock testing of brazed honeycomb test specimens is underway. It is expected that the eighteen specimens (three from each of six different parent panels) will be completed during the next report period. An outline of appropriate design techniques will be compiled. Future work on the heat shield problem will involve programming for the IBM 7090 digital computer and program checkout.

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A program will be written for a shell-and-loading condition which has an existing solution and an analysis method whose validity can be checked. The analysis method will also be checked against test data.

STRUCTURAL SUPPORT

The evaluation of Rosan inserts for use in Apollo attachments continued; comprehensive data will be issued in the immediate future.

A statistical analysis of the deviations of the burst pressures of pressure vessels was undertaken.

A summary is being prepared of environmental conditions which Apollo finishes and coatings will be required to withstand. This summary will be for use in the test of finishes for high-strength fasteners.

A study was initiated to determine the non-ablative insulation requirements in the command and service modules.

A special heat shield case is being programmed to verify the analysis method presently being investigated.

Investigation of loading simple aluminum panels is complete.

Information on toroidal filament-wound fiberglass tankage has been obtained. Effort in the field of Apollo fasteners is continuing.

Research is being conducted concerning the use of heli-coil inserts in primary structure.

A preliminary investigation into the use of fasteners made of the maraging steels has begun.

COMMAND MODULE

Metal-section determinations for the escape-launch leg-well castings on the heat shield were completed. A study was initiated to determine the materials which may impinge on the command module (urine, propellants) and their effect on command module components (ablator, windows).

The development of a Chem-Mill etchant system for Haynes Alloy No. 25 is underway. Etchant composition and control ranges, including bath analysis and surface finish, are being determined.

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The cryogenic testing of silicone rubber compounds for command module flex mounts was completed on schedule, and the final report was released.

The first Rene-41 honeycomb sandwich panel was salt-bath brazed.

The Ladish Pacific and Reisner Companies have supplied rolled-ring 2014-T6 forgings for the evaluation of mechanical properties and welding capabilities. These rings are representative of the rings to be used in the inner structure of the command module.

Ladish Pacific has also supplied forged billets of the same material to simulate the longerons.

A definition was written for minimum sandwich facing gages, adhesive bond line weights (including specification of adhesive type), limiting service temperatures, and minimum sandwich core weights and configurations was written.

All of the specimens have been radiographically inspected. The microstructure is being examined so that loss of properties during welding can be correlated with grain size and orientation.

A notch (breakaway stud design) torsion-strength test was performed on 25 breakaway studies, and a series of values were determined.

Thermal shock testing will be started on 28 honeycomb test specimens (three taken from each of six different parent panels).

SERVICE MODULE

A detail of titanium pressure vessels design and fabrication methods for titanium pressure vessels has been completed.

A test plan is under way to evaluate candidate materials for the reaction control jet flame deflector materials.

The feasibility of reducing the weight of the RCS by using a lighter honeycomb panel is being studied.

A program to evaluate progress and feasibility of the Marquardt disilicide coating for the rocket nozzles is in progress. Information regarding the thermal conditions, fuel temperature, and other significant data is being gathered.

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A dozen quarter-scale drop tests into dry sand have been completed, using vertical flight path only, heat shield up.

ATR-202, outline of the flotation test program for boilerplate 8, is in preparation. Model calculations were generated concerning the effects on bending modes of the S-IV - Apollo combination with and without the LES.

During the next report period, test requirements will be written for the fuel and oxidizer tank-joint tests. A rough draft of the combined space radiation and hard vacuum test plan is being prepared.

The engineering development laboratories program to develop and to evaluate a finish for Vascomax 250 and 300 and Vascojet 1000 high-strength fasteners is scheduled for completion.

Structures data are being prepared for 2014-T6 alloy sheet (.040 inches to .500 inches) for temperatures ranging from room temperature to 400F.

Work is continuing on the establishment of design allowables on phenylsilane reinforced fiberglass laminate.

LOADS AND CRITERIA

Launch Escape System

Loads for max q thrusting abort and for vacuum abort, both with and without tumbling, are complete for the passive system. These loads are for an 8 920 pound command module and 135,000 pounds axial thrust. They include the effect of a 250 degree-per-second tumbling rate. This rate gives an increment of 6g EBI acceleration to the astronauts, increments of 57,000 pound tension load, and up to 340,000 inches/pounds bending moment in the tower.

Work is starting on a configuration with a 9,250 pound command module and 160,000 pounds thrust.

Studies of the effect of structural deflection on thrust vector orientation during the abort sequence show that the effective thrust vector inclination changes less than 0.1 degree.

The effect of structural deflection on thrust vector orientation during the abort sequence is being studied. Consideration is being given to lateral, longitudinal, and angular deflections.

Deflections of the launch escape motor during transportation without shock attenuation were computed.

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Loads for abort conditions at maximum q in a vacuum have been computed, using existing weight and aerodynamic data with the new 120,000 pound thrust. Auxiliary (kicker) thrust values of 3400 pounds and 6000 pounds were used along with ballast weights of 375 pounds, 750 pounds, and 1500 pounds. The maximum q tumbling conditions were computed with full thrust at all angles of attack.

New weight and inertia data have been received and will be incorporated into future computations.

The effect of tower flexibility on the escape-motor thrust-vector alignment, stability, and control is being investigated. Results of this study will be incorporated in the dynamic-trajectory computer program.

A program is being written to compute the relative motion between the command module and launch escape system at the time of jettison. This will determine the necessary clearance around the tower-to-command module fittings.

Boost loads for four configurations, using a 260-inch diameter service module, have been evaluated for trade-off studies.

An investigation of loads in the payload area during transient lift-off conditions is under way.

Using the Apollo test group flexibility coefficients for the tower, frequencies and mode shapes have been computed on Saturn C-5 second stage and the Apollo escape tower and rocket on the three-stage-to-escape configuration.

Space Radiation

The calculated procedures were completed for determining secondary radiation from neutrons and protons induced in the spacecraft walls by primary solar protons.

A study of proton damage mechanisms in semiconductors has been started concerning the radiation hazards system for Apollo.

To show tissue shielding in each command module division, a graph of a primary proton dose has been prepared. From the depth and body curves, total dose is being calculated. Dose-rate equations have been developed for the evaluation of secondary evaporative protons.

Analytical methods were developed for calculation of the tolerance of photographic film to irradiation by electrons, protons and X-rays, if the tolerance to any one of these forms of radiation is known at one level.

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Data were obtained from Kodak Research Laboratory on X-ray sensitivity and the effects of fog on image resolution for several types of aerographic film.

Body Loads

Investigations of steady state and buffet aerodynamic pressure are being conducted for the service module. NASA has provided steady state data for a maximum q trajectory. These are being correlated with total-normal-force data. Buffet pressure data obtained from recent wind-tunnel tests are being reduced.

The analysis of transient transverse loads at lift-off has produced some very large loads at the command module/service module interface, but this program does not correlate with a test case. This fact and input data are being checked for error.

Boost load for four configurations, using a service module of 200-inch diameter, have been evaluated for trade-off studies.

An investigation of loads in the payload area during transient lift-off conditions is being conducted.

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RELIABILITY
(General Order 7123)

SERVICE MODULE REACTION CONTROL SYSTEM (RCS)

Reliability engineering has completed a detailed evaluation of four configurations of the service module reaction control system. The configurations investigated are a dual system composed of two redundant propellant supply subsystems supplying four clusters of four engines each; a triple system composed of four individual and independent propellant supply subsystems, each of which supplies one cluster of six engines each; a quad system composed of four individual and independent propellant supply subsystems, each of which supplies one cluster of four engines each; a quad-plus-one spare system identical to the normal quad system but with a complete propellant supply subsystem and engine cluster as an independent spare.

QUARTERLY RELIABILITY STATUS REPORT

The quarterly reliability status report was completed and will be delivered to NASA. The report includes reliability studies, design analyses, design reviews, and planned activities.

QUALIFICATION-RELIABILITY TEST PLAN

The qualification-reliability test plan was revised and transmitted to NASA for approval. A test accounting plan for major components of the spacecraft was completed as a supplement. This plan includes the number of test samples required, schedule information, environments, types of tests to be conducted, and a delineation of test objectives.

OXYGEN ATMOSPHERE STUDY

A review is being conducted to define the effects of a 5-psi oxygen atmosphere on materials contemplated for use in the command module. The materials are being categorized according to the type of possible problems (such as possible fire hazard, hazardous gases, etc.) and the effects on crew survival and mission success. Test priorities will be established, and tests will be conducted to evaluate these conditions.

SUPERCRITICAL GAS STORAGE SYSTEM

A reliability analysis of five proposed configurations for the supercritical gas storage system was completed. The recommended

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configuration involves the use of dual oxygen systems supplying the electrical power system and the environmental control system and dual hydrogen systems supplying the electrical power system.

RELIABILITY PROCEDURES AND EDUCATION

Lectures on the fundamentals of reliability mathematics are continuing and are being expanded to include Apollo engineering groups.

A course on computer methods for design analysis is also being conducted for Apollo personnel.

REVIEW OF SUBCONTRACTOR DOCUMENTATION

Five major subcontractors specifications have been reviewed for quality control adequacy. From a quality control aspect, three of the documents were satisfactory except for minor exceptions and changes which have been recommended.

Field analysis of subcontractor quality cost proposals was completed for Aerojet-General Corporation.

TRAINING AND CERTIFICATION

The following training and certification courses are now being presented to quality control inspection personnel:

- (1) space-program orientation
- (2) product inspection procedures
- (3) soldering certification
- (4) welding familiarization
- (5) visual penetrant inspection
- (6) X-ray readout

A new quality assurance specification entitled "General Requirements for the Training and Certification of Suppliers Personnel" is in preparation. As a basic policy, it will require that all items delivered by subcontractors and suppliers will meet the same standards as those employed at S & ID.

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IDENTIFICATION AND TRACEABILITY

The identification and traceability quality assurance operating procedure entitled "Lot Numbers" has been completed and is being reviewed by NASA. A 12 digit serial or lot number will be used for supplies and part identification. The first five digits will identify individual suppliers by the NASA supplier identification number and the remaining seven digits will assure individual traceability. The procedure on lot and serial numbering, J-406, is presently being rewritten to implement this new system.

A letter has been sent to NASA establishing the identification and traceability system concept. The letter includes a list of "General Category" parts which will normally not require traceability. A second letter is being prepared requesting that additional specific parts be included in the "Exempt Parts List".

QUALITY EVALUATION AND AUDIT

Nineteen performance audits were conducted during this period, and corrective and/or preventive action was initiated on 34 items. Action was completed on nine items and remedial action was initiated on the remainder. Three re-audits were conducted in previously discrepant areas and all deficiencies had been corrected. The quality control laboratory completed product audits on four parts. All characteristics evaluated were found satisfactory, and the parts were returned to stock.

DESIGN REVIEW

Quality control participation in the design/reliability analysis program is progressing at an optimum rate consistent with systems and detail design status.

SUPPLIER EVALUATIONS

Nine suppliers of parts or equipment were surveyed, and their quality control departments were evaluated during this period. Five were approved, three disapproved, and the rating of one temporarily withheld until their quality control system conforms to S&ID requirements.

FABRICATION INSPECTION - DISCREPANT ITEMS

Command module aft bulkheads are being received from purchased labor with materials review action pending on defective welding. This item is expected to be cleared soon by procurement of larger sheets of material to eliminate welding operations.

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INSPECTION PLANNING

Problem areas have developed in the implementation of inspection test instruction sheets primarily because of the lack of governing procedures. Corrective action has been taken by the issuance of QEB 1-1 that gives general instructions for the preparation and use of inspection technical instructions sheets. An additional QEB is in preparation and will be released soon to further clarify the operation. The number of production orders has increased creating a backlog of inspection technical instruction sheets.

Procurement and Fabrication quality control has issued approximately sixty procedures covering inspection and test procedures to be used by the receiving inspection department.

SPECIFICATIONS

S&ID procurement specifications are being reviewed by quality engineers. These reviews assure the inclusion of requirements for applicable documents, technical requirements, quality assurance provisions, and test. Seven preliminary procurement specifications on various components and systems have been reviewed during this period.

Existing quality control specifications are being reviewed and revised to meet Apollo requirements. This has resulted in one new and one revised specification during the report period.

HARDWARE ACCEPTANCE TESTING RESULTS

Boilerplate 25 was completed. Initial tests, performed on plant property in a plastic lined tank, were observed and documented. Subsequent tests were performed off-shore near Long Beach, California, and results were documented. All records have been transmitted to inspection technical services.

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INSTRUMENTATION (General Order 7124)

CONTROLS AND DISPLAYS

Detail drawings of the main console breadboard subpanels were completed, and fabrication of the breadboard was begun.

An analysis of the back-up entry display parameters was completed employing analog computers.

Schematic diagrams and functional descriptions of the requirements of the controls and displays of all subsystems were completed.

LOWER EQUIPMENT BAY

It was discovered that the structural kick ring in the lower equipment bay will have to be strengthened. A study of the possibility of rearranging the electronic equipment in the lower equipment bay is under way.

A mock-up of the MIT layout of the navigation guidance and display panel in the lower equipment bay is being revised according to current MIT design changes.

ELECTROMAGNETIC INTERFERENCE

The revised electromagnetic interference (EM-I) requirements, to be incorporated in the Apollo general test plan, were completed; and test requirements for boilerplates and airframes were evaluated.

The hardware utilization list of the electronic interfaces equipment to be used in simulators, evaluators, trainers, boilerplates, mock-ups, and spacecraft was completed.

The fabrication and development of test logic simulation and switching circuits for use with the in-flight test system has continued, and the roll simulator for TR-48 computer is under construction. The miniature control and display system breadboard model is being modified to improve performance and increase reliability.

A scaled-down breadboard of the in-flight test system is to be constructed during the next reporting period. NASA-furnished instrumentation items will be delivered for acceptance testing and calibration.

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TRAINING AND SIMULATION (General Order 7125)

TRAINING

Logistics and Systems Test combined into a working team for the purpose of aligning the maintenance concept and the maintenance plan into a compatible division document.

The logistics indoctrination program for new logistics employees was completed and the first presentation made during the report period.

Off-site facilities requirements for systems maintenance training have been submitted to the Apollo plant engineering department.

Training analysis work sheets; have been completed. They will aid in implementing the coordinated task and systems analysis for preparation of courses. The training function has been submitted to the training equipment design organization group.

Preparation of the logistics management training program will be completed next week. The first presentation is scheduled for September 1962.

ORGANIZATION AND PLANNING

Organization charts and formulation of objectives and task descriptions were completed, and a special task team has been set up to evaluate the Apollo simulation complex facility requirements.

SIMULATION

The F-86 simulator in Building 3 is now operational. The window study mock-up has been installed next to the simulator.

The following simulation studies were conducted or initiated:

Reentry Short Period Dynamics

Orbit Attitude Dynamics Control

Lunar Orbit Transition Dynamics

Terminal Rendezvous (halted pending clarification of the lunar orbit rendezvous concept).

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Docking (primarily docking dynamics using closed-circuit TV).

Special simulation studies, encompassing full-space mission and part-space mission simulations, have been established to make optimum use of available equipment and manpower.

Instrumentation and controls are being installed in the window study mock-up. Changes will be made in the simulator electronics, and a lunar orbital rendezvous study will start soon.

An evaluation of digital techniques for spacecraft simulation will be made using an IBM 7090 computer to simulate a segment of the Apollo stabilization and control system.

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SPACECRAFT TEST OPERATIONS (General Order 7126)

HOUSE SPACECRAFT

Checkout philosophy was presented to MIT engineering personnel during the report period.

PCM telemetry checkout philosophy was established.

The requirements for the screen room for radio frequency interference established.

Performance Specification for the PCM telemetry system checkout will be prepared.

EARTH RECOVERY TESTS

The preliminary instrumentation and data requirements list for boilerplate 8 has been prepared.

The informal sea trials of boilerplate 25 to determine general flotation and towing characteristics were monitored. This activity was conducted in the Long Beach outer harbor area and was documented in a 10-minute motion picture.

At the request of NASA, additional investigation of high-performance aircraft suitable for high-altitude prequalification flight drop testing has been halted. The investigations pertaining to balloons, helicopters, and other methods of carrying and releasing boilerplates have been discontinued.

Test planning on boilerplate 8 will continue to define detailed test plans and to accomplish the maximum number of test objectives. Conferences with NASA are planned to discuss the various aspects of the recovery mission, its definition, and its effect on boilerplate 8 testing.

ENVIRONMENTAL PROOF TESTS

Major reprogramming of the environmental proof tests has been accomplished in conjunction with the program rescheduling. To complete the entire environmental proof tests for earth orbital flights prior to manned flights, the environmental vibration and acoustic tests have been reprogrammed on AFRM 006. Environmental chamber tests will be accomplished on AFRM 008.



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The major effort during the next period will be the coordination of detailed test, support, and facility requirements in conjunction with the preparation of detailed test plans and over-all facility requirements. The PERT network will be revised in accordance with the environmental test reprogramming.

SPACECRAFT TEST PREPARATION

Effort was expended toward establishing and determining operational requirements for the spacecraft fuel cell and test requirements for the GSE/GFAE meter room equipment for Building 6A.

Preliminary checkout procedures on R & D instrumentation systems have been prepared and submitted to engineering design groups. Conferences were held with Apollo systems engineering personnel to resolve problems of integrated systems checkout procedures.

GSE requirements and delivery dates on boilerplates 6, 12, 21, 22, and 23 were established.

The interim test facility and Building 6A facility plans will be reviewed during the next period.

Test requirements for the first boilerplates to be processed through the test preparation area will be completed.

APOLLO-SATURN OPERATIONS

S&ID Apollo checkout flow concepts were presented to NASA at AMR. Many questions relating to checkout philosophies were generated by NASA-POD personnel for Apollo test operations consideration. A preliminary AMR work schedule for boilerplates 13, 16, and AFRMs 007, 010, and 011 has been completed and submitted to the PERT group to establish the AMR operations milestones.

The Apollo test and operations detail requirements for R & D instrumentation systems checkout have been determined. Functional flow charts with associated time intervals have been established for R & D data and communication instrumentation systems operation at AMR.

Flow charts and work function charts for the C-1 configuration will be updated to reflect the latest checkout concepts for the Cape Canaveral Missile Test Annex (interim) and the Merritt Island facilities. Functional flow charts with time intervals will be established for the R & D measurement system for the AMR operations.

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LAUNCH ABORT TESTS

GSE requirements for boilerplates 6 and 12 have been reviewed, and revisions have been incorporated to supply support to the partial ECS and instrumentation system. Electronic test equipment requirements to support the mission abort program at WSMR have been submitted for inclusion in SID 62-972.

Apollo Test and Operations representatives will assist in directing and monitoring the rework of the ALA3 service tower at the WSMR.

The RFWAR will be revised to reflect the program rescheduling and to incorporate the support requirements for airframes 002, 009, and 009A.

DATA ENGINEERING

The calibration data program outline was received and the pertinent general flow diagram has been prepared.

The master measurement list program has been prepared and is undergoing checkout.

Life systems data support requirements have been resolved. Two optical film reading systems will be required to support this activity. Photographic data reduction requirements have been established for the prequalification flight drop tests. A representative of Apollo data engineering monitored the fourth single main parachute bomb drop at the El Centro drop zone.

Meetings have been held with the Apollo GSE and Apollo test and operations personnel to establish GSE quantities to support all test programs through September 1964. These efforts must be reconsidered to reflect the latest schedule changes.

Checkout of the calibration data program will be started; the master measurement list program will be compiled; and reduction of the prequalification flight drop data will be begun during the next report period.

Documentation of Downey, WSMR, and AMR operational activities and their effect on the GSE configuration will be further assessed.

Preparation of GOSS operations requirements and documentation will continue. Preparation of GOSS material for the first operational review meeting will be accomplished.



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DOCUMENTATION
(General Order 7128)

The following S&ID documents were published during the month of August:

- SID 62-806 Test and Module Information for Wind Tunnel Tests of an 0.02-Scale Force Model (FSL-1) of the Apollo in the AEDC VKF Wind Tunnels "A", "B", and "C"
- SID 62-805 Test and Model Information for Wind Tunnel Tests of an 0.02 Scale Force Model (FSL-1) of the Apollo in Ames Wind Tunnels
- SID 62-930 Data Report for Apollo PS-4 Model in the AEDC Hotshoot II Wind Tunnel
- SID 62-834-1 Summary of Earth Orbital Rendezvous Studies
- SID 62-841 Pretest Report for 9.08-Scale Apollo Structural Dynamics Model (SD-1) in the NASA Langley Transonic Dynamics Wind Tunnel
- SID 62-700-1 Apollo Mission Specification
- SID 62-700-2 Apollo Spacecraft Specification
- SID 62-1007 Pretest Report for the 0.05-Scale Apollo Force Model in Ames Unitary Plan Wind Tunnel
- SID 384-11 Apollo Drawing List
- SID 62-343 Tabular Data Report for Apollo Model (FS-1) Wind Tunnel Test (SAL-199)
- SID 62-1056 Data Report for Simulated Jet Plumes on the Apollo Model (FS-1) Wind Tunnel Test (SAL 1208)
- SID 62-379 Apollo Mission Analysis
- SID 62-566-9 Apollo Still Photographs
- SID 62-1074 Data Report for Langley Unitary Plan Wind Tunnel Tests (Project 374) of Apollo Model (FD-2)

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SID 62-1065 Data Report for Langley TPT Wind Tunnel Tests (Project 233) of Apollo Model (FD-2)

SID 62-1072 Data Report for NAA Shock Tunnel Tests (ST-4) of Apollo Command Module Models H-6 and PS-6

SID 62-1063 Data Report for Apollo Model (FS-2) in Ames Unitary Plan Wind Tunnel

SID 62-1091 Apollo Navigation and Trajectory Control Trainer

SID 62-977 Data Report for Wind Tunnel Tests of Apollo Model FS-4 in the AEDC Hotshot II Wind Tunnel

SID 62-300-5 Apollo Monthly Progress Report

SID 62-99-7 Monthly Weight and Balance Report

SID 62-384-10 Drawing List

SID 62-566-7 Project Apollo Still Photograph Submittal No. 7

SID 62-995 Boilerplate 25 (Command Module) for Water Recovery Procedures and Handling Equipment Development

SID 62-204 Qualification - Reliability Test Plan

SID 62-431-1 Design Criteria Handbook (Spacecraft)

SID 62-627 Data Report for Apollo Force Model (FS-2) in NAA Trisonic Tunnel (TWT 74)

SID 62-104 Test and Model Information for Wind Tunnel Tests of an 0.105 Scale Force Model (FS-2) of the Apollo in Ames Unitary Plan Wind Tunnels

SID 62-778 Data Report for Apollo Model (FS-2) in Ames Unitary Plan Wind Tunnels

SID 62-566-8 Apollo Still Photos

SID 62-154 Quality Control Plan

SID 62-367-6 Apollo Motion Picture Documentation Submittal No. 6

SID 62-821 Radiation Shielding Status Report

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The General Test Plan (SID 62-109) is being revised and will be submitted to NASA on 30 September 1962.

Training requirements and training guides for GOSS operations personnel are revised and reissued. Spacecraft systems schematics, diagrams, and handbooks are adapted and incorporated into training packages. At the request of NASA, a plan of action to accomplish an early phase-in of GOSS operations personnel (spacecraft systems monitors) is complete and was reviewed at the GOSS meeting.

A study of the data display requirements for spacecraft systems at remote sites has been published. Work is continuing on studies for data display requirements at the Integrated Mission Control Center at Houston and the Launch Control Center at Cape Canaveral.

The Mission Abort Test Support Requirements document (SID 62-972) is published.

A preliminary measurements list for boilerplate 8 is released. The S&ID specification electromagnetic interference control for the Apollo space system is revised and released.

A revision to SID 62-98 NASA Support Manual General Style and Quality Requirements is complete. Distribution will be accomplished during the next report period.

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PROGRAM MANAGEMENT
(General Order 7129)

Amendment Number 9 was received and executed by S&ID during the report period. This amendment added \$30 million to Apollo funding for a total of \$115 million. Briefing charts and cost information were compiled, tabulated, and presented to NASA at S&ID.

Contract change authorizations have been prepared for the following:

Change of launch escape system from active to passive thrust vector control system.

Change of cabin atmosphere to 5 psia pure oxygen and deletion of nitrogen system provisions.

Modification of earth landing system.

A summary of engineering tasks caused by redefining the lunar orbital rendezvous mission concept was submitted to NASA.

PROGRAM PHASING

The NASA-S&ID schedule exercise was complete on 9 August. Agreements were reached on the key hardware completion dates and the scheduled launch dates through the first manned earth orbital flight. Key hardware changes are as follows:

1. Deletion of boilerplate 20
2. Deletion of AFRM 007
3. Addition of AFRM 009A as back-up for AFRM 009
4. Revision of mission for AFRM 011 from first manned earth orbital spacecraft to first manned earth orbital or unmanned earth orbital spacecraft
5. Revision of mission for AFRM 012 from back-up for AFRM 009 to the second manned earth orbital spacecraft

The scheduled launch date for AFRM 011 was changed from 15 September 1964 to 15 May 1965.

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The results of this schedule exercise have been incorporated into the Apollo Master Phasing Plan Number 3. This plan will be used as the basis of the firm cost proposal due 30 September 1962.

Program development schedules are currently being revised and will be included in a subsequent report.

ASSOCIATE AND SUBCONTRACTOR RELATIONS

Field analysis at AiResearch, Avco, Collins, Northrop-Ventura, Pratt & Whitney, Thiokol, and Aerojet has been concluded. A supplier has been selected for the batteries, and proposals have been received on the propellant utilization system. The inverter proposals are evaluated. Requests for purchase have been released for the battery chargers. The service module antenna is eliminated.

It is hoped that negotiation of firm contracts can be concluded with Avco, AiResearch, Collins, Northrop-Ventura, Pratt & Whitney, Thiokol, Aerojet, and Marquardt during the next period. Letter contracts will be placed for a continuation of the In-Flight Engineering study at Sperry, Utah, for the batteries, for the propellant utilization system, and for the inverter. A definitive contract is to be placed for the battery charger. The S&ID analysis of navigation and guidance requirements and schedules, set forth in the NASA letter received 22 June, was delayed in order to include any consideration introduced by the revised overall Apollo program schedule. Results of the analysis will be presented to NASA early in the next period.

Following informal coordination with General Dynamics (Convair) and NASA, S&ID's proposed Apollo/Little Joe II interface coordination and control procedure is being prepared for formal submittal to NASA and Convair for approval. A similar document, in preliminary form, is being developed for S&ID/lunar excursion module contractor interface coordination and control.

PERT

During the report period, PERT personnel reconstructed 23 new networks based upon the revised General Orders.

A revision of the Apollo master network was completed incorporating the changes necessitated by the revision to the master phasing plan and the realignment of the General Orders. The information reflected in the master net is currently being processed in the computers. This information and the revised master network will be sent to NASA during the next report period.

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STABILIZATION AND CONTROL (General Order 7130)

PRELIMINARY COMMAND MODULE REACTION JET THRUST SIZING STUDY

The preliminary command module reaction jet thrust-sizing study in progress includes an evaluation of the following:

1. Cross-range maneuver thrust requirements
2. Pull-out maneuver thrust requirements
3. Atmospheric reorientation thrust requirements
4. Disturbance and tumbling damping capabilities

PRELIMINARY SERVICE MODULE REACTION JET SIZING STUDY

Service module reaction jet system of 100-pound thrust level and 0.6 pound-second minimum impulse capability will meet the following requirements:

1. Midcourse navigation sightings at an angular rate of 0.7 minutes per second.
2. Roll control during the service module main engine thrusting for 5-degree thrust vector deflections in both pitch and yaw

The 100-pound thrust level reaction jet system will also provide adequate maneuver, adequate damping, and sufficient ullage capacity.

PRELIMINARY SERVICE MODULE REACTION JET FUEL REQUIREMENTS STUDY

A preliminary service module reaction jet fuel requirements study was completed. No failure modes were analyzed. This study was based upon the lunar landing mission using the earth-orbital rendezvous concept.

PRELIMINARY OVER-ALL STABILIZATION AND CONTROL SYSTEM STUDY

A set of simplified Apollo stabilization and control system block diagrams for 12 segments and 8 modes of flight was made. Block diagrams

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showing the interface between stabilization and control, guidance and navigation, propulsion, thermodynamics and display were prepared with control and display signals. Preliminary attitude and attitude rate requirements were established.

INERTIAL REFERENCE PACKAGE MODE VELOCITY CORRECTION

The preliminary results of the inertial reference package mode velocity corrections using sensors, rate gyros, angular and linear accelerometers, and velocity meters were obtained.

STABILIZATION AND CONTROL DESIGN

The problem of defining stabilization and control system (SCS) performance characteristics as related to mission requirements is being resolved as definite information related to specific boilerplate and airframe configurations becomes available. The preliminary boilerplate and airframe SCS requirements for boilerplates 16, 18, and airframe 001 and airframe 009 were completed and are being reviewed prior to formal release. Effort is continuing on definition of the SCS criteria for boilerplate 14 and for airframes 006, 007, 008, 010, 011, and 012.

Functional block diagrams are being prepared to describe the following mission segment SCS operating modes:

1. Launch (passive guidance and navigation command)
2. Coast (SCS command)
3. Local vertical (SCS command)
4. Sun acquire (SCS command)
5. Sun hold (SCS command)
6. Orientation for and application of ΔV (SCS command)
7. Attitude hold (navigation and guidance command)
8. Orientation for and application of ΔV (navigation and guidance command)
9. Entry (navigation and guidance command)

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Preparation of the preliminary functional block diagrams is almost complete.

A study of installation requirements for the horizon scanner and sun seeker has continued.

Preliminary work was initiated on an SCS fail-safety analysis.

The single-coil, reaction-jet, valve-driver circuit was completed and tested. Tests were initiated to determine the effects of driving two valves in series or in parallel connections.

Frequency tests were made on the boilerplate launch escape stabilization and control system amplifier-demodulator.

RADAR

Command module and service module locations for the radar transponder and antenna are being considered. Tentative locations for antennas and the service module radar were determined. The location of the radar in the command module has not been determined. There is no preference for locating the rendezvous radar.

Applicable radar systems for rendezvous were studied, and the FM/CW type was found to be optimum for the specific rendezvous requirements.

Curves for the optical beacon have been established showing the light output required as a function of star magnitude.

EVALUATION AND DEVELOPMENT

During this reporting period, SCS evaluation and development tests were conducted in the interim stabilization and control test laboratory. The preliminary evaluation of fuel valve amplifier demodulator modules and net drive circuits were completed. Fuel valve speed, response, and functional tests were started.

The command module reaction-jet thrust sizing study is to be continued during the next period.

The service module reaction jet thrust sizing study will be reevaluated.

The preliminary service module reaction jet fuel requirements study is being reevaluated in the light of the new lunar excursion module concept and new ullage requirements. A breakdown of fuel requirements for various reaction control system failures will be included.

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The second phase of the analog computer simulation program will begin during the next report period. This will be a six-degree of freedom study compared with the three-degree sets studied originally and will have a man-in-the-loop simulator with increased display information and control capabilities.

The preliminary and simplified stabilization and control system and interface block diagrams will be expanded and up-dated. Studies will be performed to resolve undefined areas and to establish interface compatibility.

Inertial measurement unit (IMU) mode velocity correction will be studied. Autopilots used for inertial reference package mode velocity corrections will be compared during the next reporting period.

Detailed test plans for the SCS simulation program and the environmental spacecraft are to be completed.

The functional block diagrams of the SCS, including all modes of operation, will be completed during the next reporting period.

The SCS criteria specifications for all applicable boilerplate and air-frame vehicles are to be completed.

An investigation of horizon scanner and sun finder mounting problems will be continued.

An investigation of the SCS-guidance and navigation interface problem will be continued.

The SCS fail-safety analysis will be continued.

Alternate rendezvous trajectories and radar locations are to be studied.

Rocket exhaust attenuation at very high and microwave frequencies is to be studied during the next reporting period.

The communication data link requirement is to be established.

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CREW PROVISIONS (General Order 7131)

CREW SUPPORT AND PERSONAL EQUIPMENT

A study to determine the effects of crew motions on spacecraft attitude control was completed. The study indicated that crew motions would have negligible effects on spacecraft attitude. Pressure-seal zippers were investigated for possible applications in sleeping restraint, in the rest compartment, and in the emergency pressure suit-donning compartment. A study of recovery areas conducted to evaluate survival gear was continued. A study of the personal parachute as an escape system in case of a recovery system malfunction is being continued. An analysis of thermal problems in connection with Apollo reentry is being continued. A study of flight and abort profiles with respect to acceleration loads is being continued. A revision of the crew couch dimensional control drawing is in progress. An evaluation of waste disposal systems by means of mock-ups and analyses is continuing. A study of individual crew radiation dosimeters is being continued. A report on post-flight ventilation requirements is being prepared.

DESIGN SUPPORT

Work on a main panel arrangement is in progress, and individual systems panels are being designed. A cursory study to determine attitude presentation compatibility by means of a three-axis ball with central action response and reference relationship is nearing completion. A general discussion of activities, results, and recommendations is in preparation and will be the basis of a report to NASA.

A study to provide recommended relocations and selections of displays for the MIT navigation and guidance panel is completed for presentation to NASA. A list of tasks required for normal routine management of the electrical power system (EPS) was completed. A study of EPS failure modes was initiated to ascertain tasks and information displays required to meet emergency situations. A study to determine the feasibility of eliminating the air lock is in progress. The study of manual over-rides for cabin air pressure and temperature controls has resulted in relocating the cabin pressure relief valve.

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GROUND SUPPORT AND CONTROL

A panel study drawing (bio-medical monitoring display) is almost complete.

The review of Life Systems Design Criteria Handbook for GSE was completed.

A list of proposed safety information and procedures for AMR was compiled.

A preliminary checklist of life systems, GSE operations, and maintenance was prepared.

CREW PERFORMANCE AND TRAINING

The planning and development of simulation studies to determine the fidelity requirements of visual displays for training simulators was completed.

Simulation test plans were evaluated to determine which may be used to provide data on human performance in the Apollo missions. Out of approximately 60 test plans, 39 were judged to be capable of providing such data. Specific human performance test objectives were developed for each of these tests and were submitted as inputs to the quarterly revision of the Apollo general test plan. One method, which measures and scores the proficiency of astronaut training performance, was roughly pretested by applying the design against data for work tasks in the earth entry mission phase. Preparations were made to present this method to NASA to explore design application problems.

An investigation was initiated to obtain data pertaining to earth and lunar rendezvous. This data will be related to various aspects of human performance capability for application in the rendezvous part-task trainer. Work was initiated on the study and analysis of malfunction insertions into the part-task trainers.

A study was completed to determine from available data a time-line analysis of Apollo flight crew visual requirements and the corresponding command module interior illumination requirements for earth-orbital, circumlunar, and lunar-orbital missions.

TASK DESIGN AND ANALYSIS

A study of the probable frequencies of crew egress/entry during Apollo missions was completed. An integrated task index of phases,

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operations, functions, and tasks was initiated for the lunar-orbital rendezvous mission. An analysis of one- and two-man operation of the Apollo spacecraft to determine the most efficient control display arrangement and astronaut task assignment is in progress.

BIOMEDICAL

A presentation concerning the biomedical aspects of the Apollo micrometeoroid problems is prepared.

Evaluation of visual problems in space continues. Included are studies of the need for red-lighted instruments, adaptations to dark conditions, glare, and possibilities of retinal burn.

S&ID is continuing an evaluation of caloric and oxygen requirements to provide energy balance during missions, regardless of the nature of environmental stress.

Recommendations for monitoring requirements of atmospheric conditions in the Apollo spacecraft are prepared. These recommendations are based on present knowledge and may be modified by the selection of materials and program results. An analysis of the effects of stress on crew performance is being continued.

OPERATIONS AND SAFETY

The safety consequences of eliminating the air lock and of fire and explosion hazards are being investigated in connection with the use of 100-percent oxygen in the command module environment.

A life systems safety provisions input was prepared for the Spacecraft Operations Manual.

A ground operational support system simulation floor plan and layout was completed.

An analysis of operator information and control requirements of the stabilization control system (SCS) and the navigation and guidance system was initiated.

A command module parts standardization and interchangeability study program is in progress to augment human factors design refinement.

An investigation of the hazards in bail-out sequence under various modes of main chute deployment failures is completed, and a report is being prepared.

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SIMULATION AND TEST

A report was completed outlining criteria and procedures for the selection of test subjects for crew performance and flight simulation test programs.

Life systems requirements for the Apollo flight simulation program are completed for inclusion in the Apollo simulation studies summary. Schedule charts are prepared showing life systems requirements and test subject utilization.

A lunar and earth-orbital dynamics attitude control simulation is completed. Three pilots completed a total of five test series each.

Life systems requirements for conversion of an F-86L simulator to Apollo mission simulation are coordinated. Arrangements were made for conversion of the Apollo window study mock-up to house controls and displays for the converted F-86L simulator.

An evaluation study of the volumetrics of anthropomorphic dummies was completed to determine compatibility with available instrumentation equipment.

A design review of the Alderson anthropomorphic dummy prototypes is in progress.

Engineering development laboratory stress tests on the restraint harness are scheduled during the next report period.

Design criteria materials and processes were established for food reconstitution bags. An initial order was placed for polypropylene material for a contoured mouthpiece. This material will be machined and then heat fused to a thermoplastic bag.

The crew support system of the spacecraft will be subjected to a dynamic test series consisting of acceleration, vibration, and acoustics. Engineering development laboratories will design a fixture that will simulate the cabin spatial arrangement and the dynamics of the crew support system.

Apollo candidate instrument lamps were subjected to environmental exposure at 10^{-9} Torr vacuum. The exposure to this environment will continue for 42 days or until the bulbs burn out.

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In support of materials evaluation, polyurethane samples are being exposed to ultra-high vacuum and various temperatures to determine sublimation rates.

During the next period, activities are projected as follows:

Human engineering boilerplate hardware design, development, and drawing releases will be continued.

Studies will be continued on lighting and vision in space, on the lunar surface, and in the command module.

A new total waste management unit will be designed.

A study of the electrical power systems (EPS) will be prepared in the near future, with emphasis on crew tasks required for normal management of the EPS, analysis of EPS in-flight malfunctions and the definition of crew tasks to cope with emergencies in the EPS, and analysis of EPS minimum display requirements.

The life system concept of checkout and monitoring consoles, reflecting typical gage and control locations on full-scale cardboard panels, will be completed in the near future.

The life systems design criteria checklist will be released.

Crew performance simulation requirements for phase 1 of the 6.3 simulation study (rendezvous) will be initiated.

Work will continue on phase 2 of the 6.1 simulation study (earth and lunar orbital), which will incorporate six degrees of freedom. Data from Phase 1 of the study was reduced, analyzed, and incorporated into a final report along with recommendations for future studies. (Performance requirements concerning test designs and methods of data recording wire prepared for phase 1 of the 6.1 simulator study for use as a preliminary means of investigating manual attitude control).

Operations and task analysis of the telecommunications system will be completed in September for use in control display design, crew performance and validation criteria development, and crew training programs.

A study designed to investigate human variable error, human constant error, and various reticle configurations for operation of a simulated space sextant will be completed.

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A list of drugs and dosages will be prepared for inclusion in space-craft medical treatment supplies.

An evaluation of biomedical considerations will be prepared concerning the performance of biochemical studies on blood, urine, and feces samples from early orbital flights.

A work statement will be prepared for the mainstream food subcontract with Stanford Research Institute.

Life systems test procedures for boilerplate 8 water egress and survival tests will be completed.

Instrument requirement boilerplate tests will be completed.

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LAUNCH ESCAPE SUBSYSTEM (General Order 7132)

MOCK-UPS

The launch escape system (LES) towers for mock-ups 9 and 11 (handling and transportation) are complete. Structural release of the towers for mock-ups 18 and 19 (complete mock-up) has been accomplished.

The conditions of maximum loading for the LES handling sling on the launch escape motor handling module have been investigated, and the stress check of the module at the sling attachments has been completed.

WEIGHT CONTROL

The LES total weight estimate presently is 6480 pounds, 580 pounds more than previously estimated. This estimate is based on the passive control system with a kicker rocket, and includes approximately 230 pounds of ballast.

STRUCTURAL DESIGN

Continued effort is being expended on the detail drawings to incorporate the passive LES provisions. Primary consideration is being placed on the flow separator and aerodynamic structural skirt and the lateral thrust motor areas.

A preliminary investigation indicates that 0.270 inches of insulation will be required to keep the flow separator temperature below 600 F.

New loads are being prepared for a tumbling abort-while-thrusting loading condition for three different ballast weights. This configuration has a flow separator commonly known as a Wiltse washer. New margins of safety will be computed for these loads.

Several detail layout changes were computed to make field installation and/or removal of the flow separator possible, prior to the escape system assembly.

Detail drawings of the flow separator and lateral thrust motor support have been released. A design study has been initiated to determine the degree of launch escape motor jet blast impingement on the tower structure. Intensive effort continues toward completion of the LES body group installation drawing.

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Various methods of energy absorption are being studied for conditions where the LES diagonals stop the forward compartment cover from being ejected under pad abort conditions.

STRUCTURAL ANALYSIS

Effective electromagnetic interference (EI) curves have been drawn in for the launch escape tower for instances when pure shear and pure moment are applied at the forward end of tower. A section-by-section EI curve has been drawn for shear that is applied 95 inches forward of the forward end of the tower. Corrected flexibility coefficients have been published.

The computer programming of a method to calculate the structural influence coefficients is continuing. An investigation is being made into techniques of inverting large matrices. Some subroutines are complete and are being checked out. A sample flow diagram is complete through the calculation of redundant moments and forces.

RELEASE MECHANISMS

A feasibility study was initiated on a system that would carry the forward heat shield with the escape tower when a pad abort condition arises.

Work on the cold-weld test is in progress. Four tower release mechanisms are involved. Present devices include two mechanisms with different machine finishes, one gold-plated mechanism, and one mechanism with plastic inserts between pins and bosses. Bearing pressures are being calculated with reduced loads to increase margins of safety of the test setups.

TEST REQUIREMENTS

The following Apollo test requirement (ATR) documents have been completed:

ATR 500	Launch Escape Tower Static Structural Test
ATR 501	Launch Escape Tower Static Firing Test
ATR 502-2	Launch Escape Tower Attachment Fitting Test
ATR 502-3	Launch Escape Tower Structural Tubing Test

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LAUNCH ESCAPE MOTOR

Agreement was reached on the general performance requirements for a revised launch escape motor which will be compatible with the recently adopted passive LES concept.

The final design and calculations resulted in a motor producing 130,000 pounds (averaged over the first 2 seconds of burning) at 20 F and 155,000 pounds at 70 F. By comparison, the previous motor was rated at 180,000 pounds at 70 F.

TESTS

Escape Rocket Static Test

S&ID has been advised that testing will not begin until 1 November, three months behind schedule. The fixtures to hold the transducers in place during the firing have been fabricated. Acquisition of test instrumentation remains a critical problem.

LES Tower Ablation Tests

Several stainless steel tubes were instrumented with thermocouples and coated with candidate ablative materials. Three additional tubes were instrumented with heat flux meters. These will also be coated leaving the calorimeters exposed. These tubes are scheduled for exposure to the exhaust of a Sparrow rocket engine.

Structural Tubing Material Producibility

A test specimen, representing tube cluster joints of the escape tower, will be tested for joint feasibility to evaluate TIG welding process. Tooling in support of this program has been fabricated and successfully tested.

For the design-allowable program, PH 15-7 Mo tubing in the annealed condition has been prepared for longitudinal tensile and compression tests. The tubing will be heat treated to the RH 1075 condition before testing. Additional sections will be welded, heat treated to RH 1075 condition, and will undergo welded longitudinal tensile testing.

FASTENERS

Maraging alloy steel (18 Ni-9 Co-5 Mo) has been selected to replace H-11 fittings previously designed for the launch escape tower subsystem. Mechanical properties will be determined over a temperature range of -423 F to 1000 F which will include tensile, notch tensile, weld tensile, compressive, and shear tests.

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A new material specification has been written for maraging steel.

During the next report period, the following will be accomplished:

Lockheed Propulsion Company will complete detail design of the revised launch escape motor, and the program schedule will be revised.

Initial development tests of the launch escape motor igniter will begin.

The development testing of igniters for the tower jettison motor will begin, and most of the tooling tryout for manufacturing tooling will be completed.

Final detailed plans for altitude simulation testing at AEDC will probably be completed.

Testing and evaluation of titanium tubing of various diameters and wall thicknesses will continue.

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ENVIRONMENTAL CONTROL SYSTEM (General Order 7133)

The 7 psia oxygen-nitrogen atmosphere has been changed to a 5 psia 100-percent oxygen atmosphere. The nitrogen system, partial-pressure sensing, and metering equipment were deleted. Substitution of the total-pressure sensing and metering equipment and subsequent modifications resulting from the adoption of this system are being accomplished.

Component weights of the ECS package remained relatively unchanged during this reporting period. A weight reduction program is progressing for the carbon dioxide and order absorber and the water separator. A significant weight reduction will be achieved for these components.

PRESSURE AND TEMPERATURE CONTROL

Deletion of the nitrogen requirements effects a command-module weight saving of 10.8 pounds. An additional saving in electrical power requirements may be realized if the suit compressors, cabin fans, and cabin heat exchangers are modified for operation at the lower pressure and density levels. (Modification of these units would result in a one-month schedule slippage by the subcontractor.)

A decision to reduce the oxygen-consumption rate from 1.8 pound per man per day to 1.25 pound per man per day would reduce lithium hydroxide requirements by 41 pounds and effect a volume reduction of 1.6 cubic feet, eliminating the existing storage problem.

Redesign of the snorkel valves has permitted command module pressure to assist valve sealing. Location of the command module vent valve is not yet resolved. Design layouts and analytical studies are in progress to determine the best location for the valve.

The reentry oxygen-supply system is being repackaged for mounting within the pressurization area of the command module.

The regenerative-heat-exchanger experimental unit is being redesigned. Preliminary testing indicated that during the bypass condition there was excessive heat transfer across the heat sideplates to the bypass gas.

A decision has been made to supply all ECS a-c components with 400-cycle power from a master power system. Studies regarding optimum frequency optimization will be discontinued.

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An analysis has been completed of the dynamic performance of suit, suit-evaporator, cabin-temperature, and water-glycol temperature controls. These temperature controls are similar in design since interchangeability is a major design objective. Shorting bars are being designed to permit the installation of any one of the controls into the various temperature-control systems.

COOLANT SYSTEM

An adhesive-bonded coldplate has been leak-tested and is now being instrumented for complete thermal tests. The first dip-brazed, sample coldplate 1/8-inch thick has been made. It is now being X-rayed to learn if the flow slots are clear of brazing flux.

A second adhesive-bonded, fully instrumented coldplate will be used for in-house thermal-evaluation tests as well as for any testing required in conjunction with externally supplied electronic boxes.

Drawings for the spacecraft service module coldplates are now being prepared.

A sketch has been completed for radial, as opposed to longitudinal, tube passages in the radiator core. Review showed that this design has a reduced pressure drop but questionable thermal performance. The rigidity characteristics are good.

Two radiator detail drawings have been completed and released on schedule. A layout for the location and mounting of isolation valves is being made. Tubing on the service module is being rerouted to increase plumbing reliability and minimize tubing runs.

A layout that will form the basis of mounting structure has been completed of the radial beam for the water-glycol system components.

A radial-beam layout that will form the structure for the mounting of water-glycol system components is complete.

WATER MANAGEMENT

The interface between fuel cells and water management is being defined in more detail. Corrective measures are being taken where equipment malfunction can cause the inadvertent isolation or dumping of fuel-cell water, hydrogen contamination of water and cabin, and over-pressurization of the storage tanks.

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The steam-vent line is being rerouted overboard through a two-inch hole in the command module heat shield. The inner surface of the discharge hole will consist of ablative material.

The water management system schematic is being revised to provide greater system versatility and redundancy, and a method of discharging excess water over-board.

Detail drawings supporting boilerplate 14 are released.

CRYOGENIC GAS STORAGE

The revision of the gas-storage-system specification is approximately 70 percent complete, and a failure-mode analysis of the system is ready for release. The gas-storage-system process specifications are 50 percent complete.

The decision to eliminate the nitrogen system resulted in a service-module weight saving of 83.1 pounds. Incorporation of the tank-support structure as an integral part of the tanks will save approximately 10 pounds.

Preliminary schematics of the GSE cryogenic-servicing-design concept are released, two layouts of cryogenic heat exchangers and valve assemblies are complete, and installation layout is in process. The requirements section of the procurement specification for cryogenic storage has been revised. A briefing on the cryogenic system was presented to NASA.

WASTE MANAGEMENT SYSTEM

A method of disposing of all waste material in a common receptacle is being studied for possible application to Apollo. This method is described in ASD Technical Report No. 61-200, "Storage Unit for Waste Material".

Various waste-disposal-system concepts are being evaluated to reduce the number of line penetrations through the pressure bulkhead.

Six waste management system detail drawings have been completed. All waste management system procurement specifications have been completed and submitted ahead of schedule. The waste management system process specification is 50 percent complete.

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TESTING AND CHECKOUT

Tests of the water separator pump are underway. The current pump configuration uses oxygen operational power. Redundancy will be accomplished by building two pumps in the same housing. The current pump design is based on an adaptation of a vacuum-operated windshield wiper employing pressure rather than vacuum.

A flow chart describing the ECS checkout concept has been completed.

Revised instrumentation requirements for the breadboard ECS are released.

A test of the cabin-outflow pressure regulator and negative-relief-valve O ring seal is complete. Good results were obtained using a square O ring groove and a Viton O ring.

MOCK-UPS

ECS layouts have been prepared and printed in support of the 1/6-scale mock-up. Final drawing release for the mock-ups is complete, and the drawings for mock-ups 18 and 19 are in process.

Updating of mock-up 5 is now being accomplished. Installation of components in the forward compartment is complete. This installation includes the latest concept of air-vent covers for the airlock and manual shutoff valves.

Components are being installed in mock-up 2. Installation of display panels, the drawers in the right-hand equipment bay, and the latest window configuration have been completed.

BREADBOARDS AND BOILERPLATES

The drawing entitled "Layout-Installation of 1-Inch Insulation for Boilerplates 6, 12, 13, 15, 20, 21, 22, and 23," is 20 percent complete. The drawing "ECS Quick-Disconnect for Inlet and Outlet Coolant Lines," is complete.

Coolant system drawings are on schedule in support of boilerplate 14. The design concept for the equipment cooling systems is approved.

A test procedure has been released for the evaluation of the functional performance of the quick-disconnect couplings to be used on boilerplate 6. A system for cooling the on-board instrumentation, telemetry, sequencer, and electrical components, has been schematically completed for

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boilerplate 6. Actual hardware for the system is available as off-the-shelf equipment. Layout drawings are in process for the cooling system for boilerplate 6. Boilerplates 12, 13, 15, 21, and 23, have the same cooling system as number 6, plus an on-board heat sink and coldplate as required. A suit-circuit drawing for boilerplate 14 and the spacecraft systems has been released.

Revised display requirements have been released for the breadboard control panel.

A series of sketches has been released which describe in detail the telemetry units specified by NASA.

A new design-control drawing has been completed which shows the dimensional envelope and a new location for the ECS umbilical disconnect.

The test chamber for the ECS breadboard test is being welded and is approximately 60 percent complete. Preliminary design for a test setup of the ECS pressure-suit subsystem has been prepared, and the test-setup schematic for the ECS integrated-breadboard test is in progress. Design of a three-man metabolic simulator is in process.

SPACE RADIATORS

The radiator panel section for the launch escape system will be evaluated during the next reporting period. Additional interface conductance tests will be conducted on the advanced-design coldplate. The test chamber shell for the ECS breadboard will be completed for pressure-proof tests. Waste management system procurement specifications will be reviewed and approved. Results of the water-glycol/ablative-material 14-day soak test (indicating swelling, crumbling, and distortion characteristics of the material) will be completed.

The following projects will near completion during the next report period:

ECS instrumentation for in-flight maintenance, checkout, controls, and displays

Breadboard test plan

Revision of the cryogenic storage system specifications

ECS equipment packaging concept

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Studies regarding the use of electrical heaters in place of water-glycol heat exchangers for cryogenic-tank-pressure control will be completed.

A summary will be prepared of trade-off studies concerned with the use of the static water separator, centrifugal water separator, and sponge-type water separator.

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EARTH LANDING AND IMPACT ATTENUATION SYSTEM (General Order 7134)

PARACHUTE SUBSYSTEM

Analysis of the third parachute drop test led to a general strengthening of the main parachute crown area. The fourth test, incorporating the reinforced crown, was conducted at nominal design conditions and was successful.

A study of main parachute riser attachment to the vehicle is complete. Five sketches of alternate means of attachment are being analyzed to determine the most satisfactory method for recovery from water only, in comparison to recovery from water or land.

Structurally reinforced parachutes designed to accommodate overweight command module conditions are being fabricated.

The parachute subsystem drop test program has been revised to include additional test altitudes and speeds.

Three drogue chutes were fabricated and packed into the deployment mortars and adjustments were made to ensure good deployment. These chutes are to be used in drop tests in 6 weeks.

The C-133A aircraft is scheduled for delivery to Douglas Aircraft Company on 1 September. It will be modified for use in the boilerplate parachute drop test. Boilerplate drop tests at El Centro are scheduled to commence 7 January 1963.

FORWARD HEAT SHIELD

The drawings of the boilerplate configuration forward heat shield latch mechanism system and its installation will be completed soon. Only minor changes of the boilerplate version of the latch mechanism system were required for adaptation to airframe (spacecraft) test vehicles, and detail layouts of the system are nearing completion.

All detail drawings of the heat shield to escape tower latch and latch assembly have been completed.

CREW COUCHES

The arm support requirements on the basic dimensions drawing have been expanded to include a movable upper arm support. Continued studies

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of methods to increase shock attenuation travel along all axes are being continued with emphasis on Y-Y axis travel.

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COMMUNICATION SYSTEM (General Order 7135)

R & D EQUIPMENT

The over-all instrumentation requirements for the propulsion test program to be conducted at White Sands have been completed and have been included in the Test Stand Design Manual. These requirements include the design criteria and installation of equipment in the test facility.

In conjunction with White Sands test, a test program outlining the measurement systems for airframe 001 was released. The program outlines the methods of data presentation, the instrumentation to be used, and the integration of the various measurement systems with the ground recording crew including requirements for systems calibration check.

Recent program revisions in the R & D instrumentation system were incorporated in the pertinent documents and drawings.

Detailed information about the R & D instrumentation system equipment for boilerplates 6 and 12 was obtained from NASA and the various equipment suppliers. Preliminary information on the measurement system for boilerplate 13 was obtained. Checkout and calibration procedures for the R & D equipment were prepared and coordinated with NASA. The procedures for the transducers used on boilerplate 6 are almost complete.

Procurement of the Q-ball angle-of-attack sensor for the abort vehicles was initiated.

On-board cameras and a timing system were selected for boilerplates 1 and 2 for airframe 005 impact tests.

A subcontractor was awarded a contract to provide the R & D beacon antenna equipment. A one-third scale model of the command module was delivered to the subcontractor.

DATA STORAGE SYSTEM

Receiving inspection and functional checkout procedures for the NASA-furnished Leach R & D recorder were prepared.

Two prototype fiberglass recorder cases were fabricated to provide shock and vibration protection for the tape recorder. A mock-up having the same weight and center of gravity as the tape recorder was made, and

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preparations for environmental testing of the cases with the mock-up installed are in progress.

The design for the installation of instrumentation on the LES for boilerplate 6 was complete, but additional accelerometers and associated amplifiers are now being added for triaxial vibration measurements on the lower end of one leg of the tower.

A design of the installation of the boilerplate 6 command module instrumentation is almost complete.

SERVICE MODULE VHF ANTENNA EQUIPMENT

The need for the service module VHF antenna was cancelled as a result of changes in program requirements. The VHF function intended for the service module installation is incorporated in the discone antenna.

PHOTOGRAPHIC EQUIPMENT

Studies were initiated to determine the fogging effects on different types of photographic film of radiation expected to be encountered on a lunar flight. Data were received on the fogging of film exposed to hard X-rays. A procedure for using these data to determine the fogging produced by particle radiation (protons and electrons) of different energies was developed, and preliminary calculations are under way to determine if additional shielding must be provided for film on board the spacecraft.

RADIATION INSTRUMENTATION

Preliminary studies were made to determine instrument location, feasibility of shadow-shielding, and methods of determining direction of incidence of radiation. Preliminary requirements were established for the number of detectors required and their location, and for information display.

SELF-CONTAINED INSTRUMENTATION PACKAGE

Data requirements for a proposed instrumented anthropomorphic dummy were received.

An investigation is in progress to select off-the-shelf recorders of high capacity and small size compatible with space and data requirements.

OPTICS

Layouts of a feasible telescope installation in the unpressurized parachute compartment were completed. The installation, which is

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compatible and is suitable for use in the lunar rendezvous mission, has a simple plane mirror in the air lock and will allow one man in the command module to accomplish docking with full visual control.

DATA FORMAT ASSIGNMENT PROCESS

A data format assignment process study is under way to develop a means for computer-deriving measurement channel assignments to the PCM commutator channels using punch-card and computer techniques.

TV EQUIPMENT

Comparative evaluation of the analog and digital breadboards was completed, and an analog TV system was selected. The selection was based on the following demonstrated and projected parameters by the participating subcontractors: (1) The digital system proved to require more development work to compete with an analog system for transmission from lunar distances. Operating parameters could not be demonstrated by the digital study subcontractor in the time required. (2) Estimated final system complexity of the digital system is much greater than the analog system.

VHF EQUIPMENT

The radio frequency intermediate frequency and audio sections of the VHF/AM receiver were preliminarily packaged in Apollo standard electronic package form for use in making layout drawings.

UNIFIED COMMUNICATIONS STUDY

Ranging and communications parameters that affect use of the space-craft deep-space instrumentation facility (DSIF) equipment during near-earth phases are being evaluated.

ANTENNA MODELS

A drawing was made for a one-third scale mock-up of the service module for use by subcontractors to determine antenna radiation patterns.

ASSOCIATE CONTRACTOR RELATIONS

Criteria for the basic system design of signal conditioners criteria were established. The MIT computer/PCM telemetry interface buffer was temporarily included as a part of the signal conditioning system pending final resolution of the interface problem.

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SPACECRAFT ANTENNA AND SENSOR STUDIES

The program for investigating high-temperature, low-dielectric properties of various materials suitable for spacecraft antenna windows and radomes is continuing.

During the next period, design, specification, and integration research for sensors and transducers will be devoted to the abort vehicles and to the propulsion tests.

The preliminary design of a power amplifier employing a traveling wave tube will be completed.

The need for high-frequency voice communications during recovery, recovery aids programming, and VHF beacon design will be evaluated.

Effort will be devoted to the unified communications study in view of the impressive reduction in communications equipment weight that can be realized. The study will consider the antenna coverage problem associated with the single parabolic antenna presently proposed for the DSIF transponder, the effect on the communications system reliability, and the modifications and attendant costs in providing a compatible GOSS network.

Cislunar communications concepts will be modified to incorporate the results that are detailed in the interim report and the results of the completed TV studies. Wide-band phase modulation for TV and voice transmission, various means of transmitting TV and telemetry synchronization information, and ranging will be studied in detail.

The synchronization study for the PCMT/M equipment will be continued with the objective of attaining an optimum code.

The results of the TV studies will be incorporated into a TV procurement specification.

Capability of the single 2 kmc high-gain antenna to satisfy communications, reliability, and safety requirements will be studied.

One-third scale service module models will be fabricated for use in pattern studies.

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NAVIGATION AND GUIDANCE (General Order 7136)

ENGINEERING

Measurement list investigation continues for navigation and guidance equipment and interface with GSE, in-flight test system (IFTS), telemetry, and controls and displays. A revised navigation and guidance block diagram is ready for distribution.

MOCK-UPS

Various fabricated parts were received, and assembly of the inertial measurement unit (IMU) and sextant was begun.

A one-half-scale cardboard mock-up of the lower equipment bay has been fabricated for use in the meetings on optical installation. Approvals have been obtained and work authorizations are in preparation for the fabrication of a full scale wooden mock-up of the lower equipment bay. This mock-up will be maintained in current status to be utilized for form factor problems of the navigation and guidance installation.

TESTING

Preliminary planning for testing in the navigation and guidance laboratory is progressing. A major portion of this effort involves consideration of guidance system accuracy expectations and the consequences for laboratory test equipment required. Results indicate that an azimuth heading accuracy of 60 seconds of arc is adequate and that precision rotation tables will not be required.

SYSTEM ANALYSIS

A preliminary 3D ascent trajectory simulation program for boost vehicle dynamics is written, compiled, and debugged. A communication instrumentation trajectory has been run for program checkout.

This program is now being revised to incorporate ten flight phases through translunar injection, including coasting periods. Various discrete signal options are also being included together with a control logic to permit study of several guidance schemes.

An evaluation of adaptive guidance planned for Saturn vehicles is under way. A simple program is used in which all inputs and computations

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are performed in an inertial frame. Nominal guided flights were run for 100, 200, and 300 nautical-mile orbits employing four different pitch steering polynomials. Selected results of a back-up navigation and guidance study group were assembled, and a report describing a back-up philosophy and system operation is being written.

The entry trajectory digital computer program is now operating. Subroutines are being written to simulate loops.

The MIT entry guidance scheme is being programmed to evaluate and resolve problem areas.

A computer study is being initiated for shaping curves on the acceleration versus time display for rough-down and cross-range control and primary system monitoring.

Mercury flight data were requested for evaluation of low level acceleration environment at the entry interface.

An error analysis was completed evaluating entry guidance schemes relative to touchdown errors. Included were rolling, lifting open-loop, and lifting closed-loop schemes.

A document was issued containing information from several sources of on-board navigation and guidance errors for the lunar mission. A document was also issued describing the alternate error instability of the IMU during entry.

As a result of investigation on the back-up midcourse guidance study, formulas were developed and programmed for the determination of an approximate orbit for the midcourse lunar voyage. The effects of photographic errors, measurement errors, and parameter uncertainties on computed velocities, positions, and entry conditions were also determined.

A back-up guidance technique study has been made which utilizes a two-body approximation method. This study is based upon the use of optical and photographic measurements and incorporates energy relationships and least-square estimates of velocity and angular momentum.

Data are being analyzed to determine thrust attitude for one-impulse return from earth orbit. The case for return from 200-nautical mile orbit and 100-nautical mile orbit is almost complete.

Earth orbital guidance effect of density uncertainties on orbit prediction was determined for various orbital altitudes.

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A simulation on transearth injection is presently being conducted to determine mechanization errors after injection for various injection techniques such as Q -matrix, explicit, and ΔV guidance.

Guidance philosophy efforts are continuing to generate guidance mechanization schemes which will result in successful rendezvous. A method of obtaining translational velocities for rendezvous, a two-dimensional guidance scheme, a three-dimensional guidance scheme, and a docking scheme are the areas which have been established.

An error-analysis propagation matrix relating injection-errors to find-errors along a circular, or nearly circular, transfer path was mechanized on the digital computer.

The minimum number of reaction jets to accomplish rendezvous is established. The number of reaction jets necessary for midcourse guidance is established. The requirements of excess fuel for rendezvous to overcome moon triaxiality effects are established. Fuel requirements for lunar ascent and transfer are being investigated in preparation for a fuel versus guidance error trade-off study.

A report is being prepared dealing with criteria pertinent to the choice of a lunar parking orbit altitude for the Apollo spacecraft complete with a lunar excursion module.

A fuel economy study is nearing completion. This study indicates that for a relatively light lunar excursion module (for example, 2200 pounds ascent payload and 4400 pounds descent payload, with an inbound and outbound hyperbolic excess velocity of 1 kilometer per second) an orbit of 550 statute miles may save over 1000 pounds of fuel over an 80 nautical mile orbit. The fuel penalty has been computed for more than 80 nautical mile orbits for a relatively heavy lunar excursion module.

Qualitative guidance considerations which should influence the choice of parking orbit altitude are being investigated.

Efforts of this past month were devoted to a study of the application of the methods of Pontryagin's Maximum Principle and Kalman's Optimum Control to the problem of optimized space flight navigation. The basic purpose of this study is to determine if these methods can be applied to the navigational problem and, if so, to what degree. Advantages and disadvantages are also being considered.

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COMPUTER ANALYSIS

A report was published which defines some of the known major navigation and guidance SCS interface problem areas. A general functional block diagram of the guidance and control system has been published.

A division and a set of double precision subroutines have been written for the Apollo guidance computer (AGC). These are being debugged on the IBM 7090 AGC functional simulator.

Work continues on the AGC mechanization of the explicit guidance technique for ascent abort guidance. A general flow chart has been prepared.

The AGC functional simulator on the IBM 7090 computer is being checked out. Work is in progress to simulate the SCS in order to complete phase 1 of system simulation.

A report describing guidance and control's flight dynamic simulation effort (Phase III) is published. The type of hardware required for AGC real-time simulation is specified.

Data on the flight table specification is being gathered, and the simulation computer requirements are being investigated.

The 3D ascent trajectory program is being debugged.

The 3D rendezvous program is in checkout.

The lunar rendezvous sensitivities program is in production.

The explicit guidance technique simulation program is in production.

The one-impulse deorbit program is in production.

The back-up transearth injection guidance system program has been coded and is being checked out.

The Apollo rendezvous homing initiation program is in checkout.

The generalized IMU error equation program is almost complete.

The checkpoint damping technique program is being checked out.

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The onboard computer sampling rate program was run successfully for one test case.

During the next period, work will continue on development of computer programs to evaluate various ascent guidance schemes. Error analysis of adaptive guidance will be performed. Effort will continue on the back-up to the primary navigation and guidance system. A study of error analysis on fuel versus error trade-off will be conducted. Reports will be written concerning the results of studies of Pontryagin's Maximum Principle and Kalman's Optimum Control as applied to space flight navigation problems.

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COMMAND MODULE STRUCTURE AND SUBSYSTEM INSTALLATION (General Order 7137)

EVALUATORS

The seat configuration for evaluator 2 is released for fabrication. This mock-up, originally scheduled as semihard mock-up 1, is now part of the evaluator program. Engineering effort is continuing to incorporate the crew couches, miscellaneous life system hardware, windows, and general interior equipment bays.

MOCK-UPS

The access doors are removed from the right hand equipment bay of mock-up 3. During the next report period, mock-up 3 will be shipped to NASA.

The latest spacecraft design information is being incorporated into mock-ups 2, 5, 8, 18, and 19. Information on the aft heat shield, compression pad fittings, and aft compartment frames of mock-ups 18 and 19 were released for fabrication. Metal couches will be used on mock-ups 2, 18, and 19. All engineering information concerning mock-up 12 is released to manufacturing.

BOILERPLATES

Test Vehicle 1

The main shell assembly and final assembly drawings are revised, and the top assembly drawing is complete.

The two impact shock strut fittings for the aft heat shield are released. Ballast and installation drawings are also released.

Test Vehicle 2

The aft heat shield complete structure and ballast installation drawings are finished. The aft bulkhead has been redesigned in an attempt to overcome problems of weld cracking. The impact shock strut fitting for the aft heat shield is released.

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Test Vehicles 3 and 19

Two detail drawings of the drogue parachute assembly are released. Design of dummy structure is being completed to simulate components other than parachute release systems in the forward compartment area. The ballast and installation drawings for these boilerplates are released and the ballast weight design for the overload condition is in work.

The forward bulkhead, the release system fairing, and drogue parachute support are released. Design and drawing effort is continuing on support structure drawings and changes required for the forward compartment cover and ejection mechanism.

Test Vehicle 5 and Subsequent Vehicles

Revised assembly drawings of the main shell and forward bulkhead are released. The aft structure drawing for the main shell is being revised, and the shock-strut release mechanism drawings are released.

Test Vehicle 6

Information for the electrical and ECS umbilicals through the aft heat shield is being incorporated into the aft heat shield drawing. The system support structure is ready for release, and two detail drawings of the drogue parachute assembly are released. The horizontal seat fittings are being redesigned and restressed. The hard-point fittings are released, and work has been initiated on the equipment racks.

Test Vehicle 8

The egress hatch is being detailed. The simulated blowout panel and air lock designs are also in work.

Crew Couches

Boilerplate crew couches are 100 percent released for boilerplate 6 and 21. The principal change from the original boilerplate 1 and 2 couch design was that structural clevis joints were incorporated between center and side couch crossbeams.

Impact Attenuation

All required impact attenuation drawings are released for boilerplates through 21. Efforts are now directed to refinement of existing designs and to studies of alternate designs with the objective of increasing reliability, reducing weight envelope sizes, and improving operating characteristics.



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Studies are being conducted to develop a passive vertical airframe shock-strut. A re-usable crew shock-strut is also being studied. Shock-strut drop tests are in progress.

Boilerplate Heat Shield

Fabrication of boilerplate heat shields is in progress. Two units are completed, and the detail sections required for final adhesive bonding of the third unit are completed. These expendable units will be utilized instead of the conventional ablative heat shields for the boilerplate test program.

STRUCTURAL DESIGN

The following Apollo Test Requirement (ATR) documents are released, they include test set-up, loads, environment, test sequence, and required data.

Command Module Tests

ATR 201	Landing Impact and Stability, Land and Water
ATR 203	Model Test - Landing Impact
ATR 205	Vibration Test of Typical Structural Tests
ATR 206-1	Vibration and acoustic Tests of Typical Service Module Panel Sections
ATR 206-2	Vibration and Acoustic Tests of Typical Adapter Panel Section
ATR 207	Escape Rocket Static Tests
ATR 210-3	Sealing of Hatch and Windows
ATR 211-3	Sealing of Airlock Components
Mechanical Device Tests	
ATR 102-5	Performance Verification of Gray and Huleguard Lanyard
ATR 103-1	Strength, Vibration, and Functional Test of Separation System of Command Module (boilerplates 3, 5, and 19)
ATR 105-1	Impact Attenuation System Component Tests Honeycomb Strut Assembly

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ATR 105-2	Impact Attenuation System Component Tests Air-Oil Strut Assembly
ATR 106-1	Evaluation of Linear-Shaped Charge
ATR 108	Forward Compartment Heat Shield Release System for boilerplates 3, 5, and 19.

HEAT SHIELD

ATR Program

All heat shield drawings for the structural component test program are released with the exception of the forward heat shield jettison fitting. This is nearing completion.

Shield Component Test

Three design studies are being conducted: removal of impact attenuation system, shift of command-module-service-module shear tie to aft heat shield, and reduction of abort rocket thrust.

A proposed test plan and data requirements were submitted for the ablative panels required in the command module entry heat shield component tests.

Proposed loadings for the command module sidewall structural component tests are being reviewed to determine if all critical conditions are included and if the applied loads agree with loadings used for analyses.

Crew Compartment

Four facing sheets and two panel drawings in this heat shield area are being revised to reflect the design installation requirements for the attitude-control pitch and yaw engines.

Twelve spacecraft drawings of the crew compartment heat shield are released, and 20 others are being completed. Detail layout effort is being directed toward the design of the window cover doors, hatch, and breakout-panel shaped-change installation.

Forward Compartment

The new launch escape tower electrical-disconnect plug configuration is being incorporated in the forward compartment heat shield basic layout. Detail drawings of the new heat shield jettison fitting are in work.

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Forward Heat Shield

The forward heat shield is being analyzed to determine the dynamic response of the structure to the ejection force. The structural deflection will show the size of an equivalent static load. This will serve as a basis for further analysis.

The forward heat shield is also being analyzed for the maximum unsymmetrical air load. Shell moments are being calculated for the indeterminate ring section between the tie-down fittings at the base. From these moments, the proper section can be determined.

Analysis of the ejector fitting is completed. The upper and lower ring analysis and the analysis of tie-down fittings is continuing. Analysis of the dome hinge and mechanism is started. The heat shield sandwich panel drawing is also being analyzed to determine the suitability of the parachute storage area of the forward compartment design for the applicable test loading conditions.

Aft Compartment

All aft compartment heat shield detail drawings are released. All sandwich panel assemblies and the assembly and insulation assembly drawings are being completed.

A study concerning the feasibility of installing the electrical umbilical through the aft heat shield by the use of a structural, integrated, removable plug was completed.

The design study for the command module-to-service module structural connection through the aft heat shield is complete. This study will be handled as a control layout for design information for structural analysis, thermodynamics, mechanisms, and Avco ablation material design.

Aft Heat Shield

Two weight studies were conducted on the aft heat shield. The first study assumed that the thrust of the launch escape system motor was reduced to 120,000 pounds. The second study assumed an 800 F temperature in the heat shield structure during impact attenuation.

A study was made in which various methods of reinforcing fastener holes in honeycomb sandwich structure were investigated including spot brazing, area brazing, indirect resistance spot welding, arc spot welding, adhesive bonding, and electroplating.

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IMPACT ATTENUATION SYSTEM

The major effort during the past month has been directed to a study of the feasibility of removing the airframe impact attenuation system. This study indicates that the system can be removed at substantial weight reduction if water landings only are considered and if the sea state is III or less. If earth landings are also considered, a substantial reduction of the impact criteria must be made to maintain the present weight. The revised impact criteria specifies horizontal velocities of 20 fps normal landing and 29 fps emergency landing. Data indicate wind velocities in excess of 34 fps may be expected 20 percent of the time.

For the sake of reliability, S&ID will maintain the airframe attenuation system until drop tests are completed and data is analyzed.

The shock strut drop tests have continued with the first full load (1500 pounds) at 22 fps. The aft heat shield release mechanism test requirements are reworked and updated.

By crowding the couches, it would be possible to double y-y axis (eyeballs right or left) stroke. The y-y condition becomes the most critical because the requirement for roll orientation prior to impact has been deleted by NASA. The increased stroke (without the aid of heat shield attenuation) is still insufficient to prevent crew injury with present landing velocity, and terrain conditions.

One solution recommended would involve modification of design criteria to require only water landing and to arbitrarily reduce maximum wind and sea state requirements. S&ID believes that this would insure crew safety as long as the entry path and the weather met specifications.

Within the present internal command module space envelope, design approaches are being taken as follows:

1. Couch structure and adjustment mechanisms are being studied for astronauts in knees-up positions during impact.
2. Removal or storage of the control system handle supports on the couch when the astronauts assume knees-up impact position is being studied.
3. Concepts involving repositioning of the crew to gain increased shock attenuation travel along each axis are being considered.
4. Methods of decreasing the total depth of the combined couch back, side beams, and lateral beams are being sought to gain additional travel along the X-X axis.

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Crew Hatch

A layout drawing is started for the outward-opening mechanical crew hatch. A purely mechanical hatch-release mechanism employing teleflex will be incorporated in this layout.

Work will start on the design of a revised flush-mounted hatch window (suitable for normal viewing) replace the present canted downward-viewing hatch window designed for lunar landing.

Astro-Sextant Doors

A drawing of the doors and door mechanisms has been prepared.

Airlock and Docking

The establishment of a basic airlock and docking design criteria were discussed with NASA. NASA prefers closed-hatch docking and one-man lock operation. S&ID bases its design on open-hatch, two-man lock operation. The S&ID system has reached the detailing stage. A mock-up and test plan release awaits decision as to which concept will be used.

S&ID proposed a new lunar excursion module docking configuration using an adapter capable of joining either the command module or excursion module to the adapter as a housing for a shock attenuation system. A preliminary study to determine shock strut size and weight for various closing velocities and g attenuations has been started.

A closed-hatch system is being considered which would entirely eliminate the air lock. Persons transferring to and from the lunar excursion module would always be in a pressurized environment. Atmospheric changes would be necessary only if they went from the command module into space. Agreement on this system can pave the way to finalization of spacecraft docking hardware.

S&ID advanced the existing air lock mechanism design by positioning the forward hatch-locking clamps outside the air lock.

SYSTEM EQUIPMENT INSTALLATION

Crew Compartment

A study has been started to determine the feasibility of obtaining more volume for the crew couch shock attenuation system by reducing

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or relocating the equipment in the crew compartment. This study is based on the possible elimination of the aft shield attenuation system.

A study is being completed concerning the effects of a major relocation and compression of equipment upon the command module center of gravity. An effort is being made in this study to move the center of gravity as far as possible in a +Z direction to make an effective increase in the lift/drag of the capsule.

A study of one concept of an umbilical plus design for the lower heat shield installation is complete. System support drawings on the fixed sextant and telescope installation are completed. A major design effort is under way to establish the interface between equipment supports and primary structure.

Forward Compartment

Final detail equipment arrangement is complete except for minor details. Studies are being made concerning the manner in which this compartment will be affected by changes in the crew compartment, caused by the proposed elimination of the heat shield shock attenuation system.

Aft Compartment

The proposed elimination of the lower heat shield shock attenuation system and the resulting changes in compartment volume requirements are being studied. Initial design work on the potable water and cooling water tank supports is complete. Layout work is continuing on propellant valve panel assembly supports and line routing supports. Electrical and hard line umbilicals in the lower heat shield are located.

STRUCTURAL ANALYSIS

Weight Control

Layouts are being prepared to substantiate the required major relocation of items in all equipment bays as a means of correcting the center of gravity problem.

The horizontal shock strut fitting on the inner cabin structure is being analyzed for loading conditions as follows:

1. Line of action of strut loads 3 degrees off the nominal with an ultimate load of 49,500 pounds tension in one cylinder and 49,500 pounds ultimate compression in the adjacent cylinder.

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2. Line of action either 0 degrees or 3 degrees off nominal with a load of 49,500 pounds ultimate, either tension or compression, acting in only one cylinder.
3. Line of action 9.5 degrees off nominal with an ultimate compression load of 49,500 pounds acting simultaneously in both cylinders.
4. Line of action 7.5 degrees off nominal with an ultimate tension load of 49,500 pounds acting simultaneously in both cylinders.

More detailed analysis is in process on the emergency blow-out panel to determine the minimum thickness permissible in this area.

A preliminary redundant load analysis of the spacecraft aft sidewall structure is being performed to provide more accurate data for the sizing of aft sidewall skins.

Forward Compartment

A study has been carried out to determine the structural effects of relocating the main parachute attachment point to give a parachute angle of 5 degrees to the X axis.

Analysis of the forward bulkhead for internal pressure and equipment tie-down is continuing. Analysis on the assumed curved beam supporting the couch attenuation system fittings in the forward bulkhead is being finalized.

Crew Couches

An analysis of the dynamics of the seat attenuation system has been conducted to determine actual seat positions for various drop heights and attitudes.

A dynamic check of the boilerplate couch was run to define the position of the seat under maximum load. This information was used to analyze the couches until criteria become available from the drop test program. A dynamic check of the seat for a vertical drop velocity of 30 feet per second was completed, and inertia loads, seat position, and onset rates were investigated.

Attenuator loads from the boilerplate analysis were applied to the couch design for a preliminary sizing of members. The couch attenuator loads were issued for design of the command module primary structure.

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AIR LOCK

An evaluation is being made of a proposed design for the main parachute attachment to the air lock top ring. Two attachment fitting design concepts have been evaluated. A study is being made to determine the axial, shear, and moment load capacity of the present design of the air lock top ring to establish docking loads.

GROUND SUPPORT EQUIPMENT

A summary report for ground support equipment loads to boilerplate command module structure is compiled and formalized.

The command module forward compartment cover sling assembly is released. Drawings for the equipment handling set are being completed. Launch escape system sling loads for the various assembly configurations were computed again.

One drawing of the tubular support base for the vehicles with fiberglass heat shields is being analyzed.

LANDING IMPACT TEST

Boilerplate 25 was test-dropped in the S&ID pool. The measured accelerations compared with the predicted accelerations are shown below:

Table 2. Predicted Versus Measured Accelerations

Drop No.	Drop Height	Vert Vel fps	Pitch Angle	Predicted G	Recorded G	Accelerometers G
1	3 ft	13.9	5 deg.	9.7	between 5&15	5, 15, 20, 40, 50
2	5 ft	18.0	5 deg.	16.2	between 20&40	5, 15, 20, 40, 50
3	5 ft	18.0	15 deg.	9.0	between 5&15	5, 15, 20, 40, 50
4	5 ft	18.0	15 deg.	9.0	less than 15	15, 20, 30, 40, 50
5	7 ft	21.2	15 deg.	12.5	less than 15	15, 20, 30, 40, 50
6	9 ft	24.0	15 deg.	16.0	between 15&20	15, 20, 30, 40, 50

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FORGED RINGS

Phase I of a feasibility study to determine whether rolled-ring forgings can be used rather than die forgings was completed. The rolled-ring forgings did not satisfy metallurgical requirements; weldability tests showed tensile strengths varied from 20,000 to 52,000 psi. Hand forgings, however, had tensile strengths of 44,000 to 52,000 psi. These strengths do satisfy metallurgical requirements.

Additional rolled rings are being evaluated with regard to metallurgical structure and a realistic minimum design allowable. An effort will be made to determine a positive method for inspecting these rings from the metallurgical standpoint. An investigation is in process to determine the optimum rolled-ring processing parameters necessary to meet the specification requirements.

ADHESIVES

The study program concerning the effect of Apollo environment on adhesives systems for structural bonding applications on the spacecraft is continuing in three phases. Phase I, tests of vacuum exposure (10^{-9} Torr) on the lap shear and honeycomb tensile test specimens, is still in progress. All test specimens for phase 2 are complete. Temperature exposure of bonded samples at 300 F and 500 F are started. A plan of action is pending for phase 3 of the program. Selection of adhesives to be evaluated will be predicted on the results attained in phases I and II.

Eight elastomeric samples were submitted to a vacuum range of 10^{-9} Torr. Preliminary results indicate only a slight weight loss in the 10^{-3} to 10^{-7} Torr range. The rate of weight loss appears to be increasing after reaching the 10^{-8} Torr range on a few of the specimens.

IMPACT ATTENUATION

Drop Tests

Flotation and stability tests on boilerplate 25 were conducted at the temporary water pool at Downey. Drops were made under varied attitudes and drop heights. The maximum sink speed investigated was 24 feet per second (9-foot drop) at a 15 degree pitch angle.

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Facilities

Detail design of the impact attenuation facility is in progress. The designs of the pendulum arms, support platform, and module stabilizer jig are nearing completion. Until the facility is completed, the command module boilerplate will be dropped from a mobile crane. These initial drops will be conducted with 30 channels of instrumentation.

VIBRATION TESTS

The test criteria for the vibration tests of structural panels have been issued. An experimental investigation of boundary conduction of various panel-to-jig mountings will be undertaken to determine the mounting method which most closely simulates the service boundary condition.

All fixtures, weights and pannels, (except honeycomb panels) have been procured for the panel vibration tests on effects of mass loading. Vibration data recording is complete on all of the aluminum and rigidamp panels in one axis. Testing is now in progress in the other axis.

ACOUSTIC THERMAL STUDY

An investigation has been started concerning available heating sources able to withstand the combined thermal and acoustic environments and able to produce heat flux magnitudes. Candidate heating elements are being instrumented with accelerometers and subjected to the acoustic environments to determine critical resonant modes. Assemblies with minor or no apparent resonant modes will be energized for short time periods and subjected again to the acoustic environment.

ABLATIVE MATERIALS

A composite specimen was fabricated from a steel plate 0.5 inch thick with a piece of Avco ablative material 0.625 inch thick bonded with Epon 931. Strain gages were attached to the outside of the ablative and to both sides of the steel prior to bonding. When loaded with a constant bending moment, the strain distribution proved to be linear through the section. At a stress level on the back of the steel of -9300 psi, the bond failed. A cantilevered specimen will be fabricated to introduce bond shear at the monitored sections.

FINISHES

Effort to acquire a suitable finish for high-strength steels is in progress. Existing finishes, in coatings thin enough to meet design tolerance specifications, do not meet corrosion-resistance or low sublimation rate requirements,

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and are subject to hydrogen embrittlement. Hydrogen embrittlement test specimen designs have been defined.

GAS GENERATOR CHARGES

Shaped charges of 10, 20, 50, and 100 charges have been tested. Optimum stand-off distances, maximum penetration depth, and propagation rate and fragmentation pattern were established. The 100 grains per foot linear charge was evaluated for capacity to cut honeycomb panel one inch thick.

Gas generator simulators and restrainers are fabricated. Temperature chamber designs are being reviewed. These chambers will be used to test gas generator charges at low and high temperatures.

Methods for simulating the forward heat shield mass and attachment points are being evaluated. This test system will be utilized in the development of gas generator charges and thruster timing.

During the next report period, development of the gas generator charges for the forward heat shield ejection system will begin; test fixtures and jigs will be fabricated. Mock-ups of tubing of various sizes will be used to determine the satisfactory timing between thrusters. Fittings for the thruster tubing will be also evaluated.

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SERVICE PROPULSION SUBSYSTEM (General Order 7138)

PROPELLANT SYSTEM

Pressurization Subsystem

A definition of requirements that will prevent propellant tank pressure from building up beyond regulator lock-up is being sought. Calculations indicate that during the coast time following long periods of engine operation the propellant tank pressures will build up to values in excess of regulator lock-up and to values in excess of the tank relief valve setting in the oxidizer tank. This predicted pressure increase is caused by temperature rise of the tank ullage and by propellant vapor saturation of the helium pressurant.

The higher pressures associated with different rates of pressure decay in the oxidizer and fuel tanks following engine restart (Figure 1) can cause oxidizer fuel ratio shifts, unpredictable thrust levels, and possible degradation of the engine.

Use of the propellants to heat the helium appears to be the most advantageous way of preventing pressure build-up. Two methods of using the propellants as a heat exchanger are under study (Figure 2). One method uses a conventional fuel gas heat exchanger. This method provides simple, automatic operation, and maintains ullage temperature close to the propellant temperature. However, propellant tank pressures during coast periods still build up to values beyond regulator lock-up because of the vapor pressure. The resulting pressure spread between the oxidizer and fuel tanks is considered too large (Figure 1).

The other method, also simple and automatic, consists of bubbling the low-pressure helium gas through the propellants. The primary advantage of this method is that it saturates the dry helium with propellant vapor at the time of use. Additional analysis of this method is intended to determine the solubility of helium in the propellants, the carry-over of gas bubbles into engine feed lines, and the turbulence surrounding the level-sensing gauge system.

Consideration is being given to simultaneous cut-off of helium source pressure when the engine is shut down. This would reduce tank pressure at the initiation of a coast period. (This mode of operation is plotted in Figure 1.)

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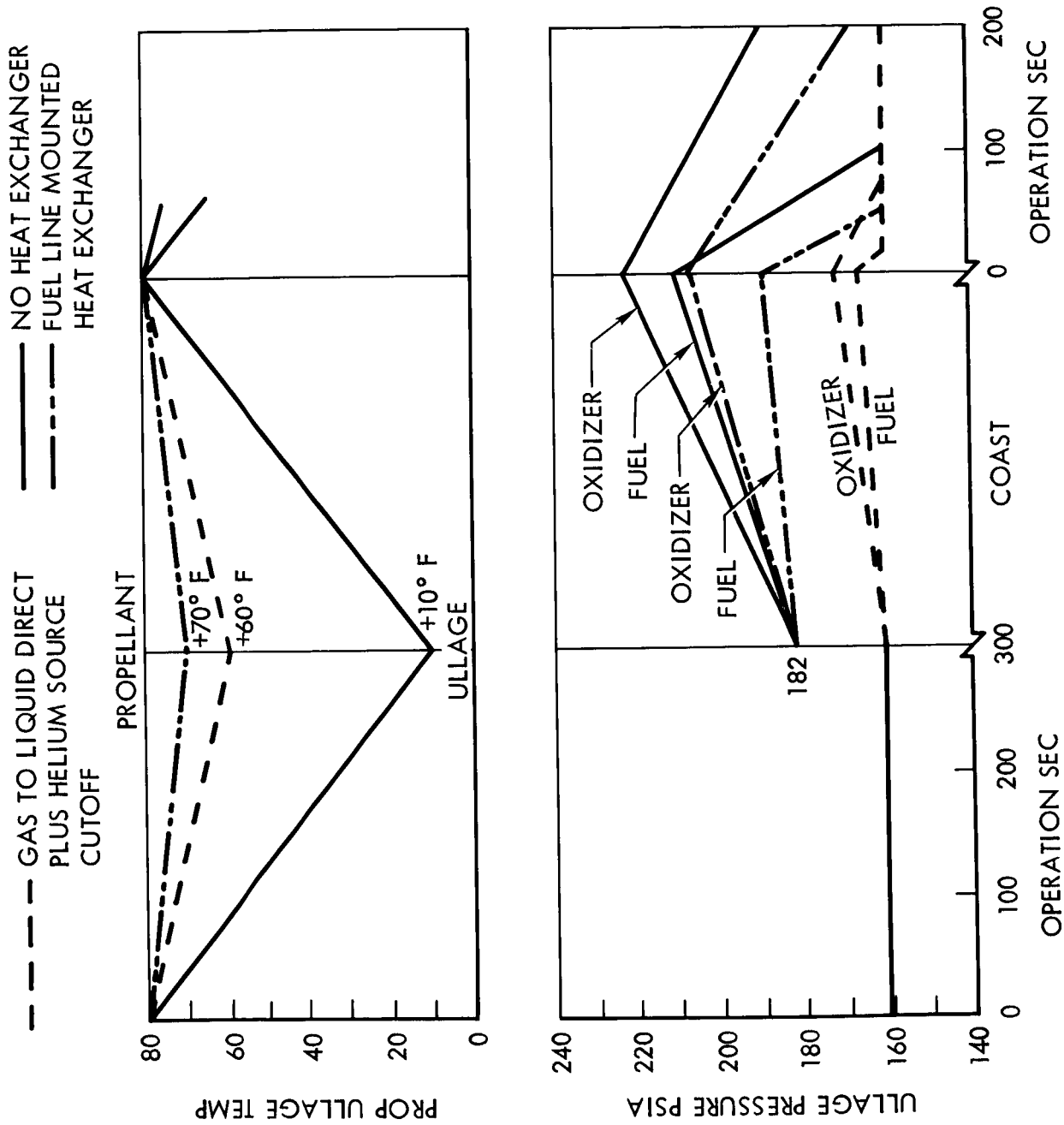
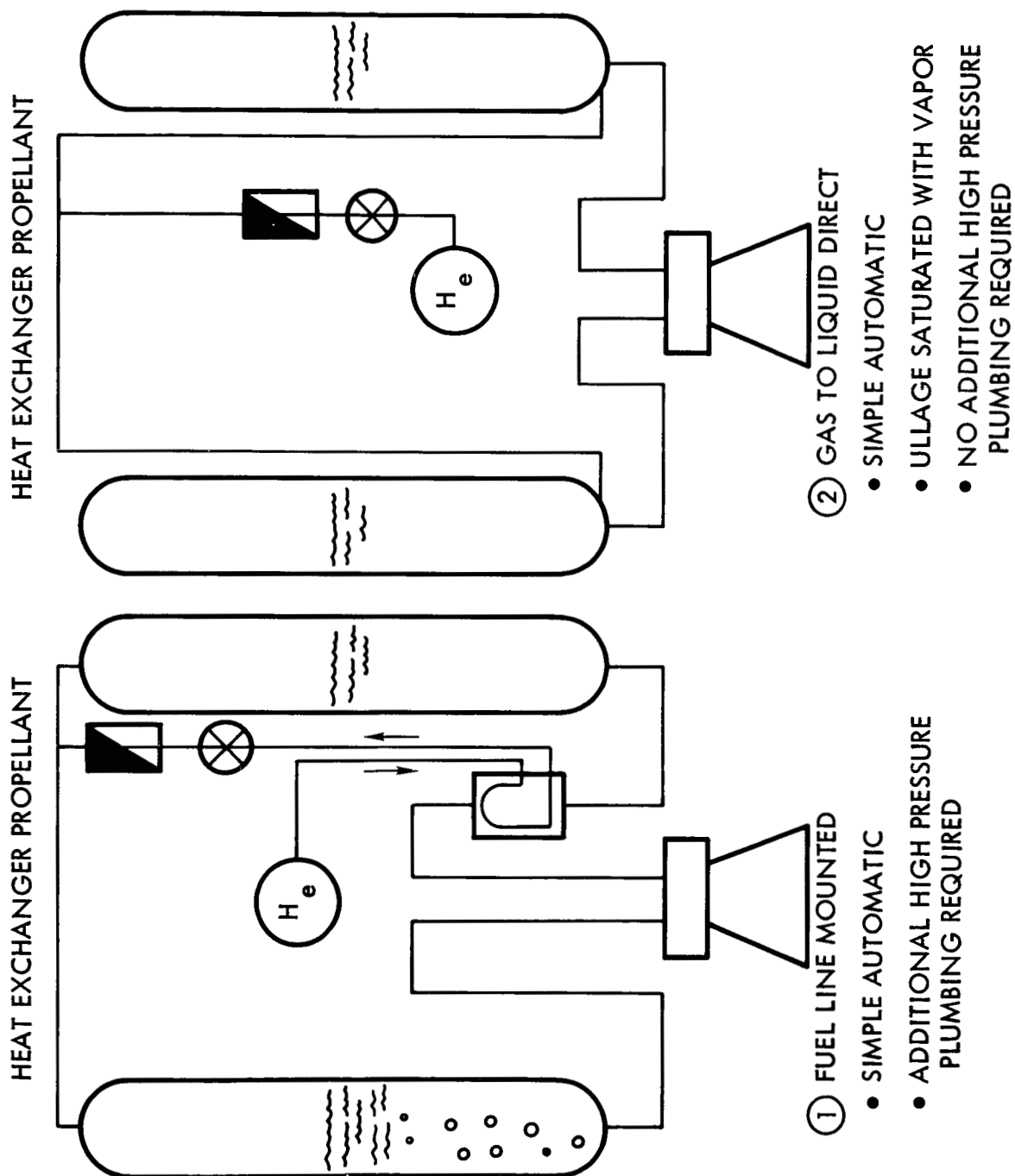


Figure 1. Preliminary Evaluation—SPS Ullage Temperature and Pressure

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During the next report period, detailed analysis of the approaches to the propellant tank pressure build-up problem will be continued.

Tank Configuration and Distribution Subsystem

The propellant tanks were lengthened to accommodate the increase of propellant quantity from 39,500 to 45,000 pounds. Tank diameters were not changed. The arrangement of tanks, with center-of-gravity excursion, is shown in Figure 3.

Design effort and upgrading necessary to meet the reliability requirements on the lengthened tank configuration will continue during the next report period.

HARDWARE

Proposals of prospective bidders on propellant utilization and gaging components are being evaluated.

Requests for proposals have been initiated and supplier bid packages are being assembled for distribution to prospective suppliers of the helium system pressure regulator.

The helium system filter specification is in final preparation.

Specifications on the helium and propellant pressure-relief valves and the propellant pressure system check valve will be released during the next report period.

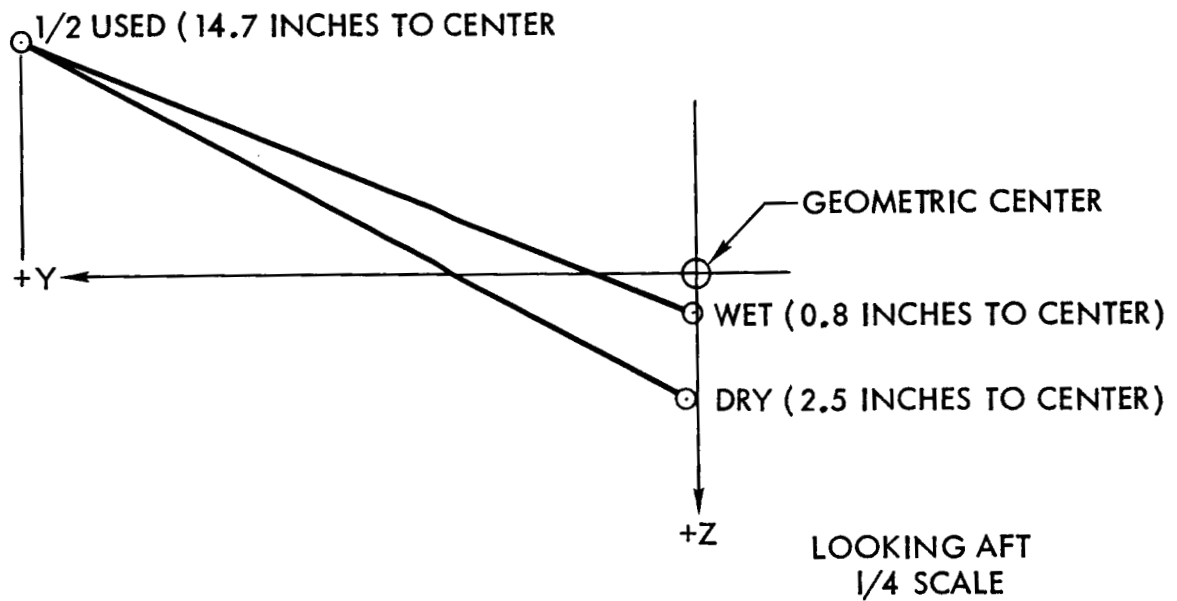
MATERIAL COMPATIBILITY

Expulsion Bladder

Continued vacuum exposure of the Stillman 634-70 butyl compound showed less than 0.5 percent weight loss after 30 days in the 10^{-9} Torr range. The compound was found to be quite permeable to nitrous tetroxide, but almost completely impermeable to Aerozine 50. The tensile strength of the compound, although relatively good after exposure to nitrous tetroxide at room temperature, was drastically reduced after exposure at 100 F.

Seal Evaluation

All the seals purchased for test have been received, and test fixtures are being completed.



ENGINE LOCATION - GEOMETRIC CENTER
 THRUST AXIS (NEUTRAL POSITION)
 CANTED $4 \frac{1}{8}^\circ$ FROM VEHICLE
 LONGITUDINAL AXIS ALONG THE
 MINUS Y AXIS
 GIMBAL TRAVEL - PLUS OR MINUS
 $9 \frac{1}{8}^\circ$ ALONG THE Y AND Z
 AXIS FROM NEUTRAL POSITION
 (INCLUDES 5° OVERTRAVEL
 FOR SPACECRAFT CONTROL)

PROPELLANT
 TRANSFER
 ARRANGEMENT

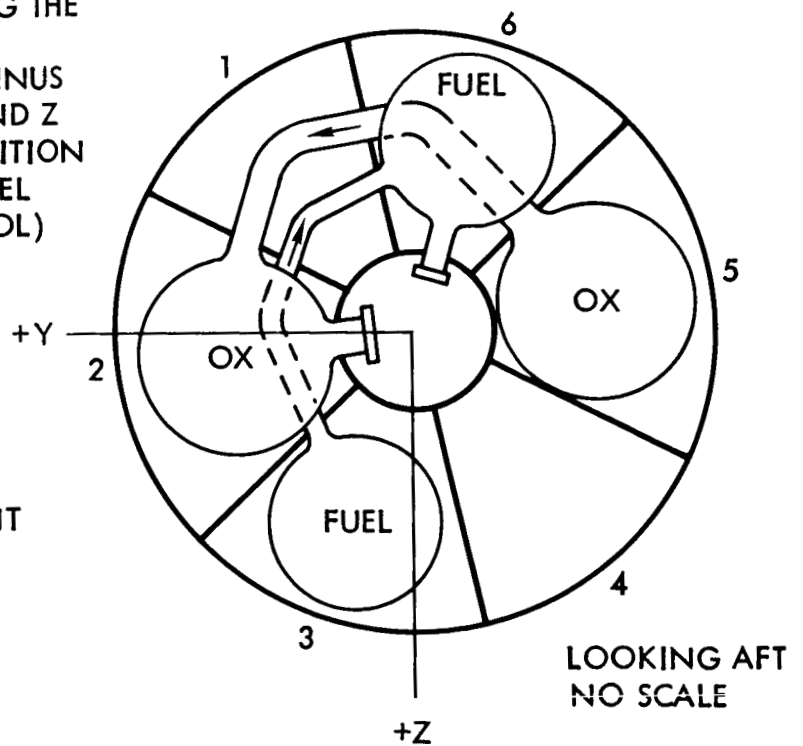


Figure 3. Arrangement of Tanks With Center of Gravity Excursion



Tube Welding and Brazing

Preparation of solder-sealed specimens with a tin-silver-antimony-indium solder compatible with nitrous tetroxide has been started. Copper-manganese-nickel brazing alloys have been found to be incompatible with nitrous tetroxide.

Union specimens have been fabricated and tube brazing has been started. Axial tension specimens of aluminum-to-CRES have been prepared, leak checked, and tensile tested. No leakage occurred until the specimens were heat treated. The shear strength was not as high as expected.

A tube welding tool has been designed and the drawing has been released for bid.

During the next report period, Phase II (complete evaluation) of the Stillman butyl compound testing will be continued. O-rings made from materials selected from Phase I tests will be used in all Phase II tests. Seal screening tests will begin, using the helium mass spectrograph. The development of the brazing process will be continued and the design of a brazing tool will be started. Test criteria for the propellant utilization subsystem will be established.

ROCKET ENGINES

Engine Installation

The position and orientations of the engine within the service module have been established. Detail layouts are now in progress to define the engine and gimbal actuator mounting provisions.

A study has been initiated to define the design requirements for the engine compartment closeout provisions. When the study is completed, the closeout design details will be established and coordinated with Aerojet for physical interface requirements.

The routing of the propellant feed lines on the engine is established. Details of the physical interface are being coordinated with Aerojet.

Test Program

Nine engine firings have been accomplished on full-scale chambers using two modified steel injectors. Some combustion instability has been observed on each firing. The runs have ranged in duration from 1.8 seconds to 2.6 seconds, the maximum for stable operation being approximately one second. Additional injectors with different hole patterns are being manufactured and tested.

~~CONFIDENTIAL~~Gimbal Actuators

The gimbal actuator performance requirements have been revised as a result of the Apollo mission redirection. The new requirements are being analyzed to determine their effect on peak and steady-state electrical power required and on gimbal actuator envelope weight.

During the next report period, one more facility (Aerojet-Azusa) will be added and will provide capabilities for thrust-chamber firings up to 200 seconds. The ablative thrust chamber will be fired to an accumulated time of 900 seconds using modified Titan injectors. The first Apollo prototype aluminum injector will be fabricated and will undergo initial firing. Complete definition of the engine vehicle interface will be accomplished. The revised engine procurement specification will be released.

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SERVICE MODULE STRUCTURE AND SUBSYSTEM INSTALLATION (General Order 7139)

MOCK-UPS

The service module for mock-ups 7 through 19 is released for fabrication.

The feasibility of reworking the 124-inch service module to make it suitable for general display use is under study.

BOILERPLATES

Because C-1 orbit capability is limited to 18,500 pounds, studies are in progress concerning the possible substitution of aluminum for 1015 steel on boilerplates 9, 13, 15, 16, and 18.

Boilerplate 6 will now include a complete spacecraft separation system. Boilerplate 9 will include a simulated system only. All boilerplates subsequent to 9 will include spacecraft separation systems as required.

Service module drawings for boilerplates 12, 21, 22, and 23 are being completed.

Work is in progress on the 155-inch long service module for boilerplate 14. Fuel and oxidizer tanks for this test vehicle are redesigned to accommodate 45,000 pounds of propellants.

WEIGHT CONTROL

Weight effects were estimated for several service module configurations. These estimates considered rearrangement of propellant tanks, which are sized for 39,500 pounds in the basic configuration, and relocation of equipment.

A study of the 260-inch diameter configuration is under way. Weight and center of gravity excursion estimates are being prepared.

Weight studies are continuing on configuration sizings for a service module with propellant capabilities up to 45,000 pounds.

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PRIMARY STRUCTURE

The design study of the effects of enlarging the base diameter of the service module to 260 inches is complete. Three configurations and five adapter-to-booster drawings are complete. Three drawings have been made showing the adapter required for the lunar orbiting rendezvous mode with the lunar excursion vehicle aboard. In the latter studies, the lunar excursion vehicle is shown inverted.

A configuration layout showing attachment of the structural shell to the radial beams, as a moment tie, has been completed. Work is under way on a layout of a configuration that has no moment capacity at the junction. Studies are continuing on the radial beam trade-offs, helium bottle support, engine support, bulkheads, and command module support.

Trade-off studies of radial beam configurations have been conducted on three major design approaches. In all instances, numerical-control-machined parts formed the major structural frame. By this method, the major load junctions at the forward and aft bulkheads were machined as integral parts, eliminating the penalties associated with structural transfer junctions.

In all studies, aerodynamic buffet loads were included. Later, wind tunnel tests determined that no buffet condition exists. The studies will be repeated without the incorporation of buffet loads as a factor.

Studies are under way to determine the optimum structural junction for the support of the lip seal for both cylindrical and tapered fairings.

Effort is continuing on the design of a service module utilizing a structural shell with a distributed load at the service module-adapter interface. Many types of the 90-degree junction of honeycomb shell to honeycomb bulkhead are being studied.

SEPARATION SYSTEM

The earlier hook concept for attaching the command module to the service module is being replaced by a concept using tension ties consisting of three studs and retention latches. The three protruding studs are attached by thermal insulators to the command module and remain there when the service module is separated. This produces a completely passive system. The mechanical portion of the system will consist of three restraining latches triggered in sequence by the retraction of the umbilicals.

A means of routing the umbilicals through the aft heat shield has been devised. Penetration is accomplished by using a structural panel with

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disconnects on either side; the umbilical, in effect, forms a wire bundle passing through multiple holes in the heat shield.

A design study has been prepared of the umbilical arm, which is pivoted to the forward bulkhead of the service module and actuated by a ballistic thruster.

RELEASE AND SEPARATION SYSTEMS

Ordnance equipment design for the lower heat shield release system, the upper heat shield separation systems, and the lower release system has been completed for boilerplate use.

Evaluation of the explosive bridge wire (EBW) and hot wire methods has led to a choice of the hot wire method for most functions. This decision is based on the desirability of simplicity, lower weight and volume, and lower cost. It has resulted in negligible change, as the system designs are compatible with either hot wire or EBW.

Tests of linear charges to cut honeycomb structure and aluminum plate have been accomplished. The linear charges will cut structure and plating for crew emergency escape by blowing a panel out of the command module. These charges will also be used to separate the adapter from the booster and the adapter from the service module.

Experimental charges of 10, 20, and 50 grains/foot sizes have been fired against aluminum plates to verify performance data. Results indicate that 20 to 25 grains/foot will be required to cut the 0.140-inch thick structure around the command module escape hatch to accomplish separation. The test program is continuing, to establish an optimum method of cutting.

SYSTEM EQUIPMENT INSTALLATION

Three design approaches have been studied to increase the capacity of the service module main propellant tanks from 39,500 pounds to 45,000 pounds. As a result of these studies, it has been decided to increase the length of the four tanks from 150 inches to approximately 165 inches and to increase the length of the service module to 155 inches to allow the tanks to remain in the same location.

The other approach considered involved adding another oxidizer tank and one more fuel tank to the system. Studies were conducted of the feasibility of locating both additional tanks in one equipment bay and of locating each of the additional tanks in a separate equipment bay.



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Studies have been initiated concerning the provision of propellant transfer line mounting in the main tanks. Dual-capacitor probes are being considered.

The main drawings for the 45,000-pound capacity propellant tank are nearing completion.

Studies to determine the feasibility of locating three fuel cells in one 50-degree equipment bay were initiated.

Two of the studies considered projecting the cells aft through the bulkhead at station 200. This method was rejected because a weight increase and added complexity resulted.

Studies are being made of connections for the fuel cells and line routings. These studies are aimed at manifolding the hard lines, keeping the oxygen separated from the hydrogen, and assuring the impossibility of lines being connected incorrectly.

S&ID has determined that the reaction control system motors may be swung downward or into the adapter area by two methods. One method calls for deployment of these motors on a single-cycle basis using powder energy. This method allows the reaction control system to be stowed in the adapter area immediately below station 200. Another approach employs electric motors for multicycle capability. This method provides stowage in the equipment bays.

A study of mechanisms which permit the antenna to slip into the equipment bay with the axis of the parabola normal to the plane of the web is being modified to conform to the lunar orbital rendezvous concept.

A design layout is in work to study support structure for the primary structure in the equipment bays. The major additional structure will consist of a partial shelf that will support a cryogenic tank and large systems equipment.

INTERNAL LOADS

An asymmetrical redundant structure program is being investigated for possible application to the latest service module configuration.

Successful geometry runs were obtained for the shell and for all frames and bulkheads in the service module and adapter structure. All adapter frames are now ready to be combined with the shell program.

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HEAT SHIELD

Optimization studies on the lower heat shield and upper bulkhead are in progress. An IBM program using the lower heat shield geometry and section properties has been run successfully.

LUNAR EXCUSION MODULE ADAPTER STUDY

Structural requirements for a lunar excusion module adapter mating the 154-inch diameter service module to the 260-inch diameter S-IVB have been completed.

APOLLO TEST REQUIREMENTS

The following test requirements, including the test set-up, loads, environment, test sequence, and required data, were released:

- ATR 301-3 service module simulated aft bulkhead test
- ATR 301-5 service module radial shear web test
- ATR 301-13 service module main propellant manhold door seal test
- ATR 304 service module aft bulkhead structural component test

It has been decided to perform a pressure vessel test on the cylindrical oxidizer tanks, cyclindrical fuel tanks, and the spherical helium tanks.

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ELECTRICAL POWER SUBSYSTEM (General Order 7140)

LIGHTING SYSTEM

A duty cycle was received for the electrical load requirements of the lighting system. Trade-off studies based on this duty cycle revealed that the incandescent lighting system would result in a more efficient use of the available electrical energy than the fluorescent system. The incandescent system is less complex because it has fewer components, requires less volume, and is lighter in weight.

UMBILICAL FEASIBILITY STUDIES

It has been recommended as a feasible concept that the intermodular umbilical be located through the command module aft heat shield. Recommendations have also been made that two insert umbilicals 6-1/2 inches in diameter be used, that critical circuits be run in-parallel through the two connectors, and that connectors separate from the electrical umbilicals be used for coax cables.

FUEL CELLS

A final decision was made to redesign the radiator and associated tubing to accommodate a 30-psi maximum pressure drop. Pratt and Whitney agreed to redesign their pump for this level.

System Design

A breadboard of an undervoltage sensing circuit for the DC bus structure was fabricated and satisfactorily tested. The package design for this unit has begun.

A bonding specification is being prepared for the Apollo spacecraft. This specification is aimed to achieve a constant, homogeneous, counter-poise for RF currents, the protection of personnel during the checkout and maintenance activities, the prevention of hazards associated with lightning discharges, and protection against the accumulation of static charges which could cause malfunctions in the electrical equipment or electro-explosive devices.

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Sequencer

Schematics are being revised for various boilerplate vehicles which will reflect the use of EBW initiation in the solid-rocket motors of the launch escape system (LES). All of the pyrotechnic functions will be initiated with hot-wire squibs. Should NASA decide on a destruct system, this would also use the EBW initiation.

The relay sequencer for boilerplate 6 was redesigned so that "hot-wire" could be initiated in the mechanical system and the LES kicker motor could be added. The decision to go "hot-wire" has delayed the fabrication and testing of the pad-abort sequencer, (including the testing of the airworthiness boilerplate).

A solid-state breadboard of the sequencer for boilerplate 13 is being fabricated for subsequent testing. Initial design is complete.

During the next period, a revised electrical system test plan will be released, testing of the undervoltage sensing circuit will be completed, a firm decision will be made regarding the direction to be taken for the lighting system, design will be completed on the boilerplate 6 sequencer, testing will be conducted on the solid-state sequencer for boilerplate 13, and hardware should be delivered for the development of the initiation system for the launch-escape-system motors.

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REACTION CONTROL (General Order 7141)

PROPELLANT SYSTEM

Design work has progressed on the service module and command module reaction control system. System studies, to the reduction of weight and to the achievement of apportioned reliability requirements, have continued and are being evaluated.

Optimization studies and reliability analysis will continue during the next reporting period.

Propellants

The solubility of helium in nitrogen tetroxide and unsymmetrical dimethylhydrazine/hydrazine must be determined, as helium pressurization will be used for the expulsion of these propellants. Adequate data are not included in available literature. Test equipment has been designed, constructed and tested, and solubility measurements will be started.

Nitrogen Tetroxide Compatibility

Immersion vessels for the test of nitrogen tetroxide compatibility with titanium alloy 6Al-4V have been devised. Forged samples are being fabricated.

A preliminary cleaning and purging specification is being drafted.

Wetting Characteristics

Measurements of the contact angles of nitrogen tetroxide and unsymmetrical dimethylhydrazine/hydrazine against the metals considered for use in the construction of propellant tanks, and Teflon, have been made. Measurements of the surface energies of the propellants have also been made. Both propellants wet all tested clean metals, and appear to wet Teflon.

Hardware

Procurement specifications for the helium system pressure regulators and the helium storage vessels have been released.

The helium system filter specification is being completed.

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During the next period, helium system check valve and pressure relief valve specifications will be released, and system component specifications will be completed.

ROCKET ENGINE

Command Module

NASA ordered all work on the command module engine design stopped, effective 2 August 1962.

Consideration is being given to a proposal that the command module engine be fabricated by Rocketdyne, using the Gemini SE-7 100-pound thruster with minimum modifications. In order to utilize the Gemini SE-7 engine, propellant system pressure must be increased, overall engine length must be decreased, and minimum pulse width must be increased.

A review of the weight penalty associated with an increase in system pressure from 190 psia to 295 psia indicates a total weight increase of 14 pounds (7 pounds per system). An anticipated increase in efficiency over the earlier engine should offset this weight increase.

The basic Gemini SE-7 engine presents a problem in the installation of the forward pitch engine. Rocketdyne indicates that the inlet valves can be moved closer to the chamber, and the end fittings can be turned 90 degrees to the line of thrust to provide the necessary clearance.

It was decided that from the onset of electrical signals, the maximum acceptable limits would be a 20-millisecond delay to reach a 90-pound thrust, and a 20-millisecond delay after signal removal to reach a 10-pound thrust. Rocketdyne says that present capabilities are slightly above these requirements.

Service Module

A configuration study has determined that service module engines would not be cooled adequately if the module were installed in a semiburied position.

Hardware

An endurance test of an experimental valve seat assembly has indicated zero leakage at 100,000 cycles.

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SPACECRAFT

A preliminary test procedure defining the AEDC altitude test program will be completed during the next reporting period. This test is designed to study plume characteristics at altitudes up to 350,000 feet.

Command Module

The RCS engine specification will be revised to reflect ablative chamber design.

Service Module

Alternate locations for the RCS engines will continue to be investigated.

The evaluation of the possibility of increasing inlet pressure for a possible performance increase and/or weight decrease will proceed.

TESTS

Command Module

Design and fabrication of the command module reaction control breadboard test fixture is approximately 75 percent complete.

Eleven of the 24 outer panels are being installed. Construction of the 12 outer panel doors is in progress. Propellant tank drawings have been released.

Test procedures to be utilized in laboratory testing of off-the-shelf components have been prepared.

During the next reporting period, additional test fixture design details will be released for fabrication, and procurement of off-the-shelf components and preparation of test procedures will continue.

Service Module

The first 100-pound-thrust engine has been installed in the aerothermo laboratory and fired for 168 seconds over eight runs.

The service module breadboard test plan reflecting the current proposed modular systems has been released.

Fabrication of the breadboard test fixture will continue during the next reporting period.

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Facilities

The architectural and engineering drawings for the interim RCS test facility have been reviewed.

The design criteria for the final reaction control development facility have received internal approval.

The contract for construction of the interim test facility will be awarded during the next reporting period.

Operational plans for the main RCS development facility will be started.

Test plans for components, using water and gaseous nitrogen as test media, will be prepared.

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SPACECRAFT ADAPTER DESIGN, FABRICATION AND ASSEMBLY (General Order 7142)

MOCK-UPS

A skin and stringer configuration of the new 135-inch adapter for mock-ups 9 and 11 (handling and transportation) is being released.

Adapters fabricated from honeycomb panels for mock-ups 16, 17, 18, and 19 are being released.

BOILERPLATES

All drawings for dynamic test article boilerplate, and orbital spacecraft boilerplates 13 and 15 have been released. These test vehicles have 105-inch adapters for 140-inch service modules.

The forward frame assembly of boilerplate 14 (house spacecraft) has been released. The adapter length for this test vehicle is being changed to 135 inches.

DESIGN AND STRUCTURES

Design studies of 220-inch- and 260-inch-diameter adapters were begun.

A weight reduction was achieved in the system which attaches the adapter to the service module by joining the adapter panels and the end frames to eliminate longerons. This arrangement provides MY/I ($\frac{\text{moment} \times \text{centroidal distance}}{\text{moment of inertia}}$) shell distribution on the adapter.

The forward frame of the service module to adapter connection is being sized; frame segments are spliced for separation as well as load transmission.

From a study of skin splices within the panels, it was found that two horizontal splices per panel were optimum. Testing of pyrotechnic devices for blow-out panels was started with a test of a 100 gram-foot shaped charge. Further test will provide data for minimum size charge and back-up material.

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A study based on loads for the 105-inch adapter indicates that a middle frame for the 135-inch-long adapter is not required. A full-size layout study of reaction control system location in the adapter has been started. A study of a C-5 adapter is in progress.

Weights and centers of gravity have been established for a service module with 45,000 pounds of propellant.

Apollo Test Requirements

The detailed requirements including the test setup, loads and environment, test sequence, and required data were completed for the spacecraft adapter side panel component test.

During the next period new design drawings will be made to reflect an adapter made up of four honeycomb panels, with loads uniformly distributed at each end of the adapter.

Development of an optimum method of attaching the adapter to the service module will continue.

The structural study of an adapter for the C-5 configuration will proceed.

Testing of pyrotechnic devices for flow-out panels to provide data for minimum size charge and back-up materials will continue.

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SPACECRAFT GROUND SUPPORT EQUIPMENT (General Orders 7143, 7144)

A preliminary draft of the Apollo checkout concept was completed.

The first draft of the GSE system concept for boilerplates 3, 5, and 19 was completed, and new information is being incorporated to reflect the latest changes.

A preliminary draft of the GSE system concept for boilerplate 6 based on the use of a checkout van at White Sands Missile Range (WSMR) was completed.

A document was released on GSE requirements and utilization for the Apollo development program and was reviewed by NASA. The NASA-requested revision of the plan was prepared and submitted.

DISPLAYS AND CONTROLS

A preliminary draft of the requirements section of the computer specification was completed.

A study of various pulse code modulation (PCM) recording techniques and the capabilities of available equipment was made.

DESIGN

Equipment requirements for the WSMR blockhouse installation were defined, and space utilization was tentatively allocated to support the White Sands test operation.

The design of an in-house explosive bridge wire (EBW) simulator is almost complete.

An investigation is in progress to determine the possibility of obtaining an EBW transducer from a subcontractor to be used as an EBW simulator.

Design work was initiated on a simulator for hot-wire squibs.

The schematics and wiring diagrams of the mobile data recorder for use in the in-house 6A control station are almost complete.

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DATA PROCESSING AND TRANSMISSION

A computer criteria chart is being prepared in tabular form to describe the over-all characteristics of several computers.

Preliminary recommendations and a block diagram of the transmission system was prepared. Camera and TV monitor recommendations for pads 34 and 37 were submitted to NASA.

ENGINEERING FACILITY REQUIREMENTS

Reports on the following engineering facility requirements are in work and are in varying stages of completion:

1. Pad and airborne abort facility - WSMR
2. Pad 37
3. Propulsion development facility², revision 1
4. AMR interim facility
5. Modification and checkout building, pad 34

The weight and balance facility report was released.

HANDLING GSE

The following items of handling GSE are presently in design:

1. Launch escape system optical alignment set
2. Command module debris tumbler
3. Launch escape weight and balance fixture
4. Spacecraft weight and balance fixture
5. Flow separator rail transfer adapter
6. Flow separator sling

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The following items of handling GSE were released:

1. Launch escape tower sling
2. Forward compartment shield sling
3. Service module sling
4. Spacecraft sling

SERVICING GSE

The two servicing GSE items released were the ground cooling cart and the ground air circulating unit.

TRAINING EQUIPMENT

Preparation of the procurement specification for digital computers for the part-task trainers was initiated. Structure layout of the simulated command module for these trainers is almost complete.

Facilities recommendations, including space layouts, voltage characteristics, and power requirements for all trainers, were forwarded to NASA.

EVALUATION TESTS

The GSE unit completed a prototype model of the EBW simulator and is assisting in the evaluation of the systems function.

The isolation amplifier breadboard evaluation and packaging of the circuit are in progress. Additional evaluation tests will be made when the prototype is completed.

Apollo GSE design has indicated that only qualitative evaluation tests will be run on the plantronics headset model MS-50. The required test setup is being assembled in the laboratories.

Breadboard circuitry will be fabricated on the circuits listed in last month's report. Evaluation and performance tests will be conducted when the breadboards are completed.

Facility and GSE

Engineering facility requirements planned for release in the next report period are:

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1. Pad and airborne abort facility - WSMR
2. Propulsion development facility, revision 1, pad 37

Handling GSE items planned for release during the next reporting period are the flow separator transfer adapter and the flow separator sling.

Items of servicing GSE to be released during the next reporting period are the fluid disconnect set, helium transfer unit, helium booster unit and liquid hydrogen transfer unit.

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GROUND OPERATIONAL SUPPORT SYSTEM
(General Order 7145)

Plots of curves were prepared for typical parking orbits, lunar injection, and translunar phase out to 30,000 nautical miles and for transearth phase from 30,000 nautical miles to atmospheric entry.

A revision of the GOSS performance and interference specification was submitted to NASA.

A work statement for Apollo back-scatter measurements is being prepared.

During the next period, study will continue on information flow, radar tracking accuracy, and GOSS network for lunar missions.

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FACILITIES

OFFICE AREAS

Program Management, Engineering, and other Apollo office areas now occupy 175,000 square feet. In July, 1962, 159,000 square feet was occupied.

An area in Building 6, Downey, adjacent to engineering has been assigned for the NASA Apollo engineering staff.

NASA has approved the plan to rehabilitate the Northrop-Ventura California facilities at El Centro and Salton Sea. The earth landing system test drops will be made at these sites.

The Avco appendix "A" was submitted to NASA for approval during the report period.

Appendix "A" for Minneapolis-Honeywell, Pratt & Whitney, and Collins Radio will be submitted during the next report period.

MANUFACTURING AREAS

Facility work was started on the trainer fabrication area of Building 43 in Compton. Building 1 modifications (installation of additional overhead cranes) were started during the report period. Approximately 25 percent of the design of Apollo manufacturing material handling equipment has been completed to date.

During the next report period, an area will be set up for fabrication of Apollo test requirements spacecraft. Construction will be continued on the trainer fabrication area. The manufacturing area will be rearranged to accommodate new spacecraft tooling.

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FACILITIES PROJECTS

Predesign site surveys have been started for the propulsion systems development facility at White Sands. Submittal of design criteria for the propulsion systems development facility to NASA was held pending receipt of new ground rules.

Design contracts were let and design is in process on the facilities listed below:

Plaster master

Impact test

Systems integration and checkout

Radiographic

Bonding and test

Parking

During the next report period, the design criteria for the space systems development facility and the reaction control system facility will be submitted. Addenda to the design criteria for the bonding-and-testing and for the systems integration-and-checkout facilities will also be submitted as a part of that package.

Design contracts for the space systems development facility and the reaction control system facility will be let during this period.



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APPENDIX

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Table A-1. Meetings August, 1962

Subject	Location	Date	S&ID Representative	Organizations
Fuel Cell Interface Meeting	Downey, California	1 August	Nash, Mackay, Barnett, Day	S&ID, Pratt and Whitney
Gantry Modification Coordination	White Sands, New Mexico	1 - 2 August	Kennedy	S&ID, NASA
Little Joe II- Tower Test Discussion	White Sands, New Mexico	1 - 2 August	Jacob	S&ID, NASA
Hydrogen Engine Review	West Palm Beach, Florida	1 - 2 August	Field, Simkin	S&ID, Pratt and Whitney
General Plan Revision Discussion	Houston, Texas	1 - 3 August	Selague, Williamson	S&ID, NASA
Schedule Test Meeting	Houston, Texas	1 - 3 August	Emrich	S&ID, NASA
Reentry Simulation Studies	Houston, Texas	1 - 4 August	Klein	S&ID, NASA
Quality Control Plan Discussion	Los Angeles, California	3 August	Griffith-Jones, Martin	S&ID, AiResearch
Heat Shield Subcontractor Meeting	Wilmington, Massachusetts	3 - 10 August	Palmer, Conger, Hamfin, Jacob, Walkover, Nelson	S&ID, Avco
Computer Complex Briefing	Greenbelt, Maryland	5 August	Schepak, Moorehouse	S&ID, NASA
Life Systems Integration Meeting	Long Island, New York	5 - 6 August	Wishon	S&ID, Alderson Research Laboratories
Navigation and Guidance coordination	Cambridge, Massachusetts	5 - 7 August	Phillips, Rose, Percy	S&ID, MIT
Wind tunnel tests	Mountain View, California	5 - 15 August	Ufer, Sola	S&ID, Ames
Maintenance analysis procedure	Los Angeles, California	6 August	Parker, Pollard, Wolfe	S&ID, AiResearch
Technical biweekly meeting	Houston, Texas	6 - 7 August	Longino, Kronsberg	S&ID, NASA

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Table A-1. Meetings August, 1962 (Cont)

Subject	Location	Date	S&ID Representative	Organizations
Flight power systems meeting	Moffet Field, California	6 - 7 August	Johnson	S&ID, Ames
Titan II propulsion development	Denver, Colorado	6 - 8 August	Grycel, Henry, Robertson	S&ID, Martin-Denver
Entry analysis coordination	Moffet Field, California	6 - 8 August	Klein, Miller, Timothy	S&ID, NASA, ARC MIT
Fuel cell and qualifications test meeting	Hartford, Connecticut	6 - 9 August	Champaign, Nash	S&ID, Pratt and Whitney
Flight test panel meeting	Houston, Texas	6 - 9 August	Gildea, Lowry, Dudek, Fouts	S&ID, NASA
Wind tunnel tests	Tulahoma, Tennessee	7 - 9 August	Allen, Miller, Shurr	S&ID, AEDC
Vehicle coordination (Max "Q")	Houston, Texas	7 - 9 August	Charnuck, Silverman	S&ID, NASA
Heat shield integration	Wilmington, Massachusetts	7 - 9 August	Hanfin, Confer, Walkover	S&ID, Avco
GSE checkout meeting	Houston, Texas	7 - 10 August	Triman, Morland	S&ID, NASA
Power system panel biweekly meeting	Houston, Texas	7 - 10 August	Field, Peterson, Gibb, Jacob	S&ID, NASA
PS-1 Tests	Moffet Field, California	7 - 17 August	Cola	S&ID, Aerodynamics
Biweekly mechanical systems meeting	Houston, Texas	8 - 9 August	Stevens, Korb, Nicholas, Opdyke	S&ID, NASA
Gemini mock-up review	El Centro, California	8 - 10 August	Young	S&ID, NASA
Associate contractor coordination meeting	Cambridge, Massachusetts	8 - 10 August	Stratton	S&ID, MIT
Life systems effort coordination	Houston, Texas San Antonio, Texas	8 - 12 August	Wells, Echmeir, Erickson	S&ID, NASA



Table A-1. Meetings August, 1962 (Cont)

Subject	Location	Date	S&ID Representative	Organizations
Reference data procurement	San Diego, California	9 August	Mundy	S&ID, Convair
Little Joe II coordination meeting	San Diego, California	9 - 10 August	Gatewood, Gately, Robinson	S&ID, Convair
Heat transfer meeting	Davenport, Iowa	9 - 12 August	Davis	S&ID, Bendix
GSE requirements and reliability meetings	Cambridge, Massachusetts	9 - 15 August	Morland, Russell, Trimman, Fatton	S&ID, MIT
Integration coordination	Houston, Texas	9 - 24 August	Silverman	S&ID, NASA
Management coordination	Downey, California	10 August	Todd	S&ID, NASA, MIT
Lunar excursion module simulation evaluation	Columbus, Ohio	10 - 11 August	Pearce	S&ID, NAA-Columbus
Ballistic missile and space technology	Colorado Springs, Colorado	10 - 17 August	Simkin	Symposium
Wind tunnel tests	Buffalo, New York	10 - 20 August	Karydas	S&ID, Cornell
Checkout procedures	AMR	12 - 16 August	Haight, Butler, Clauss	S&ID, NASA
Heat shield and ablation	Wilmington, Massachusetts	12 - 17 August	Charbourne	S&ID, Avco
Quality test plan	Hartford, Connecticut	12 - 17 August	Nash, Synder	S&ID, Pratt and Whitney
AIEE energy conversion conference	San Francisco, California	12 - 17 August	Dutzi	Symposium
Training plan coordination	Cedar Rapids, Iowa	12 - 18 August	Smith	S&ID, Collins
Field analysis test operations	El Centro, California	13 - 14 August	Bielefeld, Ellis, Large, Young	S&ID, USN



Table A-1. Meetings August, 1962 (Cont)

Subject	Location	Date	S&ID Representative	Organizations
Mechanical integration flight dynamics	Houston, Texas	13 - 15 August	Gatewood	S&ID, NASA
Instrumentation and calibration discussion	Morristown, New Jersey	13 - 15 August	Shelley, Schepak	S&ID, RCA-DEP
GSE and fuel cell meeting	Hartford, Connecticut	13 - 15 August	Symons	S&ID, Pratt and Whitney
Biweekly crew systems meeting Food effort discussion	Houston, Texas	13 - 16 August	Dewitt, Hair, Brewer, Tarr	S&ID, NASA
Facilities coordination	AMR	13 - 16 August	McKim	S&ID, NASA
Solar flare methods survey	Los Alamos, Albuquerque, New Mexico	13 - 18 August	Pickney	S&ID, NASA
Test matters coordination	AMR Houston, Texas; Tulsa, Oklahoma	13 - 19 August	Cranston	S&ID, NASA NAA - Tulsa
Tower jettison motor plans	Tullahoma, Tennessee	14 - 15 August	Bellamy	S&ID, AEDC
Biweekly technical panel meeting	Houston, Texas	14 - 16 August	Gildea, Erickson, Smith	S&ID, NASA
Gemini mock-up review	St. Louis, Missouri	14 - 16 August	Pyle	S&ID, NASA
Biweekly technical meeting	Houston, Texas	14 - 16 August	Gildea, Erickson, Smith	S&ID, NASA
Mechanical integration panel meeting	Houston, Texas	14 - 17 August	Nicholas, White	S&ID, NASA
Equipment installation coordination	Minneapolis, Minnesota	14 - 19 August	Peters, Mayers, Gasparre, Frost Jr.	S&ID, Minneapolis-Honeywell
TV review study	Cedar Rapids, Iowa	15 - 16 August	Albinger, Pope	S&ID, NASA, Collins

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Table A-1. Meetings August, 1962 (Cont)

Subject	Location	Date	S&ID Representative	Organizations
Biweekly facilities coordination	Houston, Texas	15 - 16 August	Erickson, Smith	S&ID, NASA
Tower and configuration control	White Sands, New Mexico; El Paso, Texas	15 - 17 August	Dodds, Wolfe, Jacob, Leonard, Rogers, Dorian	S&ID, NASA
Wind tunnel test	Moffet Field, California	15 - 29 August	Swenden	S&ID, Ames
Reaction control motors discussion	Houston, Texas	16 - 17 August	Benner	S&ID, NASA
Test program review	Mountain View, California	16 August	Woody, Barnett	S&ID, Ames
Theoretical and experimental investigation	Baltimore, Maryland	17 - 20 August	Hackett	S&ID, Martin- Marietta Corporation
Bimonthly industrial support meeting	Huntsville, Alabama	17 - 23 August	Cooper	S&ID, NASA
Pretest meeting	Hampton, Virginia; Buffalo, New York	17 - 24 August	Karfiol, Biss	S&ID, NASA, Cornell
Instrumentation coordination effort	Concord, California	18 - 19 August	Dunham	S&ID, Systron Donner Corporation
GSE briefing and facilities coordination	Houston, Texas	19 - 22 August	Triman, Eckmeir, Zeminick, Cooper	S&ID, NASA
Scoring methods, design, and human factors conference	Columbus, Ohio; Dayton, Ohio; Houston, Texas	19 - 24 August	Wolfe, Tilden	S&ID, NASA, USAF
Pretest conference	Newport News, Virginia; Hampton, Virginia; Wilmington, Massachusetts	19 - 24 August	Sherr	S&ID, Avco
Shock tunnel coordination and aerojet testing				

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Table A-1. Meetings August, 1962 (Cont)

Subject	Location	Date	S&ID Representative	Organizations
Heat shield subcontractor coordination	Wilmington, Massachusetts	19 - 24 August	Palmer	S&ID, MIT
Biweekly flight technology meeting	Houston, Texas	20 - 21 August	Gershun, Lundgren	S&ID, NASA
Equipment and checkout preparation	Houston, Texas	20 - 21 August	Nowicki, Jones	S&ID, NASA
Monthly progress review meeting	Cambridge, Massachusetts	20 - 21 August	Morland, Beck	S&ID, NASA, MIT
MA-7 debriefing	Houston, Texas	20 - 21 August	Robinson, Nelson, Maxwell, Antletz, Templeton, Lu, Rabideau	S&ID, NASA
Checkout meeting	Houston, Texas	21 - 22 August	McNerney, Allen, Triman	S&ID, NASA
Boilerplate discussion	Houston, Texas	21 - 22 August	Petrey, Hillberg	S&ID, NASA
Pretest conference	Hampton, Virginia	21 - 23 August	Gillies, McNary	S&ID, NASA
Electrical systems design coordination	Houston, Texas	21 - 28 August	Miller, Carey	S&ID, NASA
Little Joe II interface coordination	San Diego, California	22 - 23 August	Gately, Milerson	S&ID, Convair
Biweekly mechanical systems meeting General electric presentation	Houston, Texas	22 - 24 August	Johnson, Stone, Sakai, Delast	S&ID, NASA, General Electric
Scoring methods briefing	Houston, Texas	22 - 24 August	Traux	S&ID, NASA
Training equipment evaluation	Houston, Texas	22 - 25 August	Smith	S&ID, NASA
Gemini heat shield	St. Louis, Missouri	22 - 25 August	Nixon, Gershun, King, Morant	S&ID, McDonnell
Shock tub coordination	Boston, Massachusetts	23 - 24 August	Biss	S&ID, Avco

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Table A-1. Meetings August, 1962 (Cont)

Subject	Location	Date	S&ID Representative	Organizations
R & D vehicles coordination	Houston, Texas	23 August - 9 September	Leonard	S&ID, NASA
Fuel cell mounting coordination	Hartford, Connecticut	24 - 29 August	Derbyshire, Anderson	S&ID, Pratt and Whitney
Batteries, presentation	Houston, Texas	26 - 27 August	Ottinger, Toomey, Reed	S&ID, NASA
Saturn-apollo interfaces	Huntsville, Alabama	26 - 30 August	Gaare, Robinson, Millenson	S&ID, NASA
Controls and displays presentation	Houston, Texas	27 - 28 August	Martin, Cambell, Bagley, Curstun, Brochmon, Wingo, Brewer	S&ID, NASA
GSE briefing	Tulsa, Oklahoma	27 - 28 August	Asbury	S&ID, NASA
Configuration and design meeting	Houston, Texas	27 - 28 August		S&ID, NASA
Gas analyzer meeting	Houston, Texas	27 - 28 August	Solitario	S&ID, NASA, AirResearch
Structural integration meeting	Huntsville, Alabama	27 - 30 August	Warner, Novak	S&ID, NASA
Parachute drop tests	El Centro, California	27 - 30 August	Ellis, Waudby, Bielefeld	S&ID, USN
TV review study	Cedar Rapids, Iowa	28 August	Pope, Levine	S&ID, Collins
AIChE national meeting	Denver, Colorado	28 - 29 August	Taylor	Symposium
GOSS meeting	Houston, Texas	28 - 29 August	Pope, Longino	S&ID, NASA
Biweekly crew systems meeting	Houston, Texas	28 - 30 August	DeWitt	S&ID, NASA
R&D instrumentation coordination	Houston, Texas	28 - 30 August	Walker, Kuznicki	S&ID, NASA

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Table A-1. Meetings August, 1962 (Cont)

Subject	Location	Date	S&ID Representative	Organizations
Simulation meeting	Philadelphia, Pennsylvania	28 August - 3 September	Shiffman	S&ID, General Electric
Test site configuration negotiations	Las Cruces, New Mexico; El Paso, Texas	29 - 30 August	Jacob, Dorian, Rogers, Cooper, Kennedy	S&ID, NASA
Guidance and control biweekly systems meeting	Houston, Texas	29 - 30 August	Kennedy, Jansen, Yee, Quebedeaux	S&ID, NASA
Leach tape coordination	Houston, Texas	29 - 31 August	Bernhard	S&ID, NASA
Tower jettison motor and installation research discussion	Elkton, Maryland; Silver Springs, Maryland	29 August - 3 September	Warne, Bergeren	S&ID, Thiokol
Heat shield meeting	Wilmington, Massachusetts	30 August - 2 September	Gersham, Stone, Morant, Confer	S&ID, Avco